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SURVEYING WITH THE
TACHEOMETER

SURVEYING

WITH

THE TACHEOMETER

*A PRACTICAL MANUAL FOR
THE USE OF CIVIL AND MILITARY ENGINEERS
AND SURVEYORS*

INCLUDING
TWO SERIES OF TABLES SPECIALLY COMPUTED FOR THE
REDUCTION OF READINGS IN SEXAGESIMAL AND
IN CENTESIMAL DEGREES

BY
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Second Edition



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B. A. Rodgers

PREFACE.

ON the continent of Europe an acceptable system of Tacheometry has met with acknowledged success for over half-a-century; but, strange to say, as yet it has scarcely been adopted by British engineers amongst their systems of surveying. The only plausible excuse that can be given for this apparent indifference is that tachometers were always manufactured with the unusual graduation of 100 degrees to a right angle; but this objection ought to disappear with the perfected method of making the reductions described in the text.

It is hoped that the descriptions will clearly explain the general principles upon which the system is built up, and give an adequate idea of the manner of applying them to practice.

Although the method of Tacheometry described in detail is undoubtedly that which lends itself to most universal adoption, yet two others are mentioned very briefly.

The various Tables will be found of practical use to any one engaged in the class of surveying with which we are treating. Those referring to centesimal degrees, added for the benefit of operators who may still prefer that graduation, are arranged from a set kindly given to the writer by Mr. A. S. Truman, M.Inst.C.E.

May, 1900.

CONTENTS.

	PAGE
THE TACHEOMETER DESCRIBED	1
ADJUSTMENTS OF THE TACHEOMETER	6
THE MEASUREMENTS OF HEIGHTS AND DISTANCES BY MEANS OF THE TACHEOMETER AND STAFF	12
THE STAFF	18
FIELD WORK	20
OFFICE WORK	29
OTHER METHODS OF TACHEOMETRY	38
APPENDIX I.—SAMPLE OF FIELD BOOK	43
APPENDIX II.—TABLE FOR REDUCING DISTANCES AND HEIGHTS (ORDINARY DEGREES)	47
APPENDIX III.—TABLE FOR REDUCING DISTANCES AND HEIGHTS (CENTESIMAL DEGREES)	81
APPENDIX IV.—TABLE FOR REDUCING CENTESIMAL GRADU- ATIONS TO SEXAGESIMAL, AND VICE VERSÂ	103

DEVAPRASAD BHATTACHARYYA.

SURVEYING WITH THE TACHEOMETER.

THE TACHEOMETER DESCRIBED.

THE satisfactory representation in plan of a piece of country in which any public work is projected has always been a desideratum with engineers. For many years they were contented to study the location of their works by means of longitudinal and cross sections taken along a series of traverse lines which approximately followed the adopted route, all field-work being laboriously executed by the use of chain, theodolite, level and staff.

Gradually the necessity for improvement was felt, and several systems of preparing preliminary surveys and plans have been put forward. These have been grouped into two main divisions, viz.: "Those intended for the approximately accurate determination of long distances; and those intended for the exact determination of short ones." * The latter group, so far as topographical work for engineering studies is concerned, is that which has stood and is standing all tests in the most satisfactory manner.

* General Walker.

2 SURVEYING WITH THE TACHEOMETER.

In the first quarter of the past century the Italian engineer Porro gave great attention to this subject; and later, his work was systematized by the French engineer Moinot. The instrument evolved from their labours is now called the Tacheometer. By its use, in conjunction with a graduated staff, preliminary plans are produced much more rapidly, and giving infinitely more detail, than by the older methods.

The tacheometer is simply a transit theodolite fitted with a powerful telescope, the construction of which is represented graphically in Fig. 1. Horizontal wires, (*a*) and (*b*), are placed in the diaphragm at equal distances from the line of collimation. *O* is the object-glass. At a distance *OQ* less than the focal length of *O*, is placed a lens *Q*, whose focus falls between *Q* and *O* at *E*.

Rays of light that reach the wires (*a*) and (*b*), say from points *A* and *B* on a staff, strike the object glass at (*m*) and (*n*), where they are refracted in the directions *mE* and *nE* so as to pass through the focus *E* of the lens *Q*; and continue in those directions until *Q* is met. From *Q* they emerge parallel to the axis of the telescope, finally striking the wires (*a*) and (*b*). The lines *Bn* and *Am* prolonged meet in the point *F'*, forming there an angle, *BFA*.

In any other position of the staff, such as *B'A'*, the rays *A'm* and *B'n* which arrive at the wires (*a*) and (*b*) will form the same angle at *F'*.

This angle is called the "measuring angle."

The axis of the instrument is made to correspond with its apex *I'*; and to this point all distances and heights are referred, as afterwards to be explained.

A telescope thus arranged is said to be "anallatic," and this ingenious device (invented by Porro) has been the chief means of bringing telescopic measurements within the field of practical surveying.

A tachcometer made by Troughton and Simms is shown in Fig. 4. This particular instrument transits with the object-glass downward; but if so desired the instruments are also made to transit with the eye-piece downward.

One of the small bubbles is attached to the horizontal plate, and the other, *A*, is connected to the vernier arms of the vertical circle.

The zero of the vertical circle is in the vertical line; whilst its verniers are set horizontally, thereby avoiding the necessity of specially indicating whether the telescope is pointed upwards or downwards—as is the case when the horizontal diameter is adopted as the zero of this circle.

The clip screws at *B* adjust the vertical circle, one of them being turned by a key which is only fitted to it during the process of adjustment. A similar detachable key fits in at *C*, and actuates the arrangement for adjusting the measuring angle. The wires in the diaphragm are represented in Fig. 2. Those marked *aa'* produce a measuring angle, twice the tangent of the half of which is 0.02; and

4 SURVEYING WITH THE TACHEOMETER.

those marked bb' produce another angle, twice the tangent of the half of which is 0.004. These numbers are called the "constants" of the instrument.

The eye-piece can be moved up or down by a pinion so as to obtain a clear sight of the extreme wires.

The compass is of the detachable box pattern.

The vertical and horizontal circles of this tacheometer are divided into the ordinary sexagesimal degrees of ninety to a right angle.

Here it is necessary to state that on the continent of Europe centesimal degrees of one hundred to the right angle have hitherto been used almost exclusively for the divisions of the tacheometer. This method of estimating angles, originally proposed in France in connection with the universal system of weights and measures, presents facilities for the use of a slide rule in making the reductions to be afterwards explained; but it has nothing else to recommend it.

Recently Mr. Gustave Gillman, A.M.Inst.C.E., has invented an ingenious yet simple diagram which affords equal facilities for effecting these reductions with any system of dividing angles, and in consequence the supposed necessity for a graduation other than the ordinary one of 360 degrees to a circle has now entirely disappeared.

It is more than probable that the peculiar division of 400 degrees to a circle, by which ordinary trigonometrical tables are rendered useless, has hitherto caused the use of the tacheometer to be

looked upon with suspicion by English engineers ; but now that the method of reductions has been practically perfected, let us hope that instrument-makers will entirely abandon this system, using sexagesimal degrees exclusively ; and that engineers will realize that in the modern tacheometer they possess the most universal instrument that has ever been offered to them for carrying on preliminary surveys, definite locations, or indeed any of the many operations for which an ordinary transit theodolite is used.

Surveyors and engineers ought never in the future to purchase a theodolite as now ordinarily constructed, but to insist on the makers supplying it with a distance-measuring telescope such as is fitted to the present tacheometer.

Indeed, the tacheometer is nothing but a perfected transit theodolite.

ADJUSTMENTS OF THE TACHEOMETER.

THE following are the permanent adjustments of the tachometer, and it is advisable to execute them in the order given.

FIRST.—*To place the plane represented by the level attached to the horizontal plate, perpendicular to the vertical axis.*

Place the level parallel to two corresponding levelling screws; bring the bubble to the centre of its run by means of the levelling screws; turn the instrument through 180 degrees; assuming that the bubble is not now in the centre of its run, bring it so, one half by means of the levelling screws, and one half by means of its own adjusting screw; continue this operation until the bubble remains in the centre of its run on being turned through 180 degrees. Next, place the level parallel to the other levelling screws, or screw in the case of a tribrach instrument, and repeat the same operation until the level “reverses” in its new position.

Continue the foregoing operations until the bubble remains in the centre of its run in any position of the level.

SECOND.—*To place the line of collimation perpendicular to the rotating axis of the telescope.*

Direct the telescope to some well-defined object, and bisect it by the vertical wire of the diaphragm ; turn the instrument through 180 degrees in azimuth, and again point the telescope to the object ; if it be bisected as before, the adjustment is perfect ; if not, correct half the error by the screws holding the diaphragm, taking care to release one before its opposite is tightened.

THIRD.—*To place the rotating axis of the telescope truly horizontal.*

If a striding level is supplied with the instrument, this adjustment is best carried out by its means ; but if not, proceed as follows :—

The instrument being properly set up and kept carefully levelled, direct a sight, the bubble of telescope upwards, at a well-defined fine mark, No. 1, considerably above the instrument, 30 ft. or so if possible ; turn the telescope downward and mark as low as possible a spot, No. 2, cut by the vertical wire ; revolve the upper part of the instrument through 180 degrees ; rotate the telescope and again sight the elevated mark ; turn the telescope, now bubble downward, and observe the low mark ; if it be cut, the adjustment is correct ; if not, slacken the lock nut which works in connection with the clip screw at *B* (Fig. 4), and this screws itself ; make another mark, No. 3, where the sight strikes at the side of No. 2. Halfway between Nos. 2 and 3 place mark No. 4, which will be plumb beneath No. 1 ; by means of the

screws supporting one end of the rotating axis, raise or lower that support until, after a sufficient repetition of the foregoing operations, mark No. 4 is sighted; the adjustment is then finished and the screw at *B* (Fig. 2) can be secured.

A good place for effecting this adjustment is against the wall of a house, the elevated mark being put on the wall through an upper window. The instrument ought to be close to the wall, in fact nearly as close as the focus of the telescope will allow. A plumb line is sometimes used, but there is nearly always a difficulty in keeping it sufficiently steady.

FOURTH.—*To make the zero line of the vernier coincide with the horizontal diameter (90° — 270°) of the vertical circle, when the line of collimation is truly horizontal.*

The instrument being set up and carefully levelled, direct the telescope, bubble upwards, to a well-defined mark; make the intersection of the vertical and central horizontal wires coincide with the top of the mark (the top of a ranging rod set up some 200 yards distant is very suitable); note the vertical angle (No. 1) marked by the vernier; revolve the upper part of the instrument and direct the telescope, bubble downwards, to the mark; note the vertical angle (No. 2) marked in this position; the sum of the two angles ought to be 360° if the adjustment is correct; if not, add or subtract, as the sum of the angles is greater or less than 360° , half the difference from angle No. 2; make the vernier

correspond to this corrected value of angle No. 2 by means of the tangent screw of the vertical circle; this will have shifted the central horizontal wire from the top of the mark; by means of the clip screw at *B* (Fig. 4) make the central wire coincide with the top of the mark. The instrument ought now to be in adjustment, but a repetition of these operations is necessary until perfect correction is obtained.

This adjustment ought to be examined once every day. It is so important that the following examples are given:—

Reading No. 1 (bubble upwards)	85° 1'
Reading No. 2 (bubble downwards)	274° 45'
	<hr/>
Sum	359° 46'
	<hr/>
Difference to make 360°	+ 0° 14'
Half of difference	+ 0° 7'

Hence, had the instrument been in adjustment the readings ought to have been—

No. 1	(85° 1' + 0° 7') =	85° 8'
No. 2	(274° 45' + 0° 7') =	274° 52'
		<hr/>
	Sum	<u>360° 0°</u>

The instrument will be standing with its vertical circle indicating reading No. 2, so we will proceed by making its vernier read 274° 52' by means of the tangent screw, and then by means of the clip screws at *B* (Fig. 4) bring the central horizontal wire into coincidence with the top of the object or pole sighted.

10 SURVEYING WITH THE TACHEOMETER.

The next example shows a case with the sum of the readings in excess of 360 degrees.

No. 1 (bubble upwards)	: . .	89° 38'
No. 2 (bubble downwards)	: . .	270° 27'
Sum		<u>360° 5'</u>

Difference to make 360 = 0° 5' .

Half difference = 0° , 2' 30" ,

Hence the correction of 0° 2' 30" must be subtracted, and reading No. 2 must be made 270° 24' 30" before making the horizontal wire correspond with the object sighted.

FIFTH.—*To adjust the levels attached to the telescope and the vernier arm of the vertical circle.*

With the instrument well levelled and after the previous correction has been made, place the vertical vernier to zero; then the bubble of the level *A* (Fig. 4) and that of the telescope ought to be in the centres of their runs. If not, bring them to the centres by means of their adjusting screws.

SIXTH.—*To adjust the measuring angle.*

On as level a piece of ground as possible measure off a line of moderate length, say 150 yards or metres, and place pegs at its extremities. Over one peg set up the tacheometer and on the other a staff marked with divisions of a size subsequently to be described.

When the instrument is levelled up, place the telescope horizontal and sight the staff. The number of divisions between the extreme wires ought to

indicate the distance measured from peg to peg. If this distance is not correctly indicated, turn the key which fits in at *C* (Fig. 4) until the number of divisions between the upper and lower wires indicates it exactly.

THE MEASUREMENTS OF HEIGHTS AND DISTANCES BY MEANS OF THE TACHEOMETER AND STAFF.

THE staff used in connection with the tacheometer ought to be not less than 14 feet in length, and broad enough to allow of marking with clear, bold figures.

Suppose BAC (Fig. 3) to be the measuring angle of a tacheometer whose apex is at A , and whose containing lines strike, at B and C , a graduated staff held at right angles to AD , the central line of sight. BC is equally divided in D , and AD represents the distance between the staff and the apex of the angle, or the axis of the instrument.

$$\text{Then } AD = \frac{BD}{\tan BAD}$$

$$\text{but } BD = \frac{BC}{2}, \text{ and the angle } BAD = \frac{BAC}{2}$$

$$\text{therefore } AD = \frac{BC}{2 \tan \frac{BAC}{2}} \quad (1)$$

The solution of this equation is practicable because BC is the space observed through the telescope between the points B and C struck by the wire ; and $2 \tan \frac{BAC}{2}$ is known from the

construction of the instrument, being, in fact, the “constant” already referred to on page 4.

To put this more simply, let k represent the constant of the instrument, which is the value of $2 \tan \frac{BAC}{2}$, Q the space read on the staff, and S the distance between the staff and the apex of the measuring angle; then we have, in place of equation (1)—

$$S = \frac{Q}{k} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Now, instead of marking the staff in the units of measurement, let the size of each division on the staff be made equivalent to a unit of measurement multiplied by k , the constant of the instrument, and supposing that g represents the number of these new divisions observed between the wires; then Q , the actual space, will be g , the number of divisions, multiplied by the size of one division, or—

$$Q = gk, \text{ hence}$$

$$g = \frac{Q}{k}$$

but by equation (2)—

$$S = \frac{Q}{k}, \text{ therefore}$$

$$S = g \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

This shows that (g), the number of these special divisions read on a staff, gives at once the distance between it and the apex of the measuring angle, which coincides with the main axis of the instrument.

14 SURVEYING WITH THE TACHEOMETER.

An example will show more clearly the great advantage of this simple device.

The measuring angle usually put in the tachemeters made by Messrs. Troughton and Simms is, such that the constant $k = 0.02$. Should it be desired to measure in yards, then the divisions on the staff will be $1 \text{ yard} \times 0.02 \text{ yard}$, that is $\frac{1}{50}$ part of a yard, or 0.72 inch. If upon looking with a tacheometer at a staff thus divided, seventy-five of these divisions are included between the wires, then the staff is seventy-five yards distant from the instrument; if $100\frac{1}{2}$ divisions are included, it is $100\frac{1}{2}$ yards distant, and so on.

When the metre is used as a unit of measurement the size of a division is 2 centimetres.

Some instruments are made with other measuring angles.

Take one with a constant such that $k = 0.03$, and assume that it is desired to measure in feet, then the divisions on the staff would be $1 \text{ foot} \times 0.03 = 0.03 \text{ foot}$, that is 0.36 inch in size.

Hitherto we have assumed the line of sight to be at right angles to the staff; but in actual work this is seldom practicable, and it becomes necessary to direct the telescope at a suitable angle to the staff held vertically as in Fig. 5.

Assume that the central line of sight, IO , strikes the staff at O , forming an angle V with the vertical, whilst the wires forming the measuring angle strike it at M and N .

Through O draw a line at right angles to OI ,

striking the line of vision of the wires at m and n ; then OI will represent S in equation (3), mn will represent g , and let the number of divisions read between M and N be represented by G .

It may be well to point out here that it is the number G which is always read in practice, and that it is called the "generating number."

Owing to the small size of the measuring angle, the lines of sight formed by the wires are so nearly parallel that the angles MmO and NnO may be taken as right angles, and the triangles MOm , NOn may be considered as right-angled triangles, whose angles mMO and nNO are equal to V ,

$$\begin{aligned}\text{so that } mO &= MO \sin V \\ \text{and } nO &= NO \sin V\end{aligned}$$

adding these equations $mO + nO = (MO + NO) \sin V$;

$$\begin{aligned}\text{but } mO + nO &= mn, \text{ that is } g, \\ \text{and } MO + NO &= MN, \text{ that is } G; \\ \text{therefore } g &= G \sin V\end{aligned}$$

$$\begin{aligned}\text{By equation (3) } g &= S \\ \text{hence } S &= G \sin V\end{aligned}$$

In Fig. 5 the horizontal distance D between the instrument and the staff; the vertical height H between the axis of the instrument and the point O , where the central line of sight strikes the staff; and that line of sight itself, or S , form a right-angled triangle, in which the side S and the angle O equal to V are known.

$$\text{Then } D = S \sin V$$

and replacing S by its value of $G \sin V$, just found, we get—

$$D = G \sin^2 V \quad . \quad . \quad . \quad (4)$$

which gives a value for the horizontal distance between the instrument and the staff, in terms of the angle formed by the line of sight with the vertical and the number of divisions read on the staff between the wires.

The height H is deduced thus from the horizontal distance—

$$H = D \cotan V \quad . \quad . \quad . \quad (5)$$

or directly from G , the generating number, by substituting for D its value in equation (4)—

$$H = G \sin V \cos V$$

When V is more than a right angle, that is when the telescope points downward, then equations (4) and (5) become—

$$D = G \cos^2 (V - 90^\circ) \quad . \quad . \quad . \quad (4a)$$

$$H = D \tan (V - 90^\circ) \quad . \quad . \quad . \quad (5a)$$

By taking into account the height (m) in Figs. 6, 7, and 8, between the station on which the staff rests and the point where the central line of sight strikes the staff, the difference of level is obtained between the main axis of the instrument and the station.

Let (a) and (b) represent the number of divisions read between the base of the staff and each place where the wires cut it, then $\frac{a+b}{2}$ gives the number of divisions between the ground and the point struck

by the central line of sight. This number multiplied by the size of one division (k) gives the height (m) in units, that is—

$$m = \frac{(a + b) \times k}{2} \quad . \quad . \quad . \quad (6)$$

It has already been mentioned that the usual size of divisions is 0.02 of a unit of measurement, so when this is the case—

$$m = \frac{(a + b) \times 0.02}{2} \text{ or}$$

$$m = \frac{a + b}{100} \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

The operation involved by this equation is of the simplest, as it only consists of adding together the readings of the wires and placing a decimal point in front of the second figure from the right-hand side.

The combinations of rises and falls that occur between the instrument and a station on which a staff is placed are shown in Figs. 6, 7, and 8.

In Fig. 6 there is a rise, and the difference of level is $H - m$.

In Fig. 7 there is a fall, and the difference of level is $H + m$.

In Fig. 8 there is also a fall, although the telescope points upwards, and the difference of level is $m - H$.

When the difference of level between the ground at the instrument and at the staff is required, it is necessary to measure with a tape the height of the axis above the ground, and to make this allowance.

THE STAFF.

THE staves used in connection with the tachometer ought never to be less than 14 feet in length, and they ought to be broad enough to allow of marking them with clear, bold figures.

It has already been pointed out that the size of the divisions is a unit of measurement multiplied by the working constant of the instrument being used.

When the constant is 0·02, and the metre is the unit adopted, there is nothing special to notice, as divisions of two centimetres are in every respect suitable.

With the foot, however, the best method of marking is not quite so evident, as with the usual constant the divisions become too small for distant readings.

Two methods have been suggested for overcoming this difficulty:—

(a) To adopt the yard as a unit and divide the staff into 0·02 of a yard (0·72 of an inch) which gives quite a bold graduation. Levels, however, must be expressed in feet, so an extra column in the field book becomes necessary, which will consist of the reduced levels as found in yards multiplied by three to bring them to feet. This process has

the further advantage that for the general reductions of the field book one figure less will nearly always be used in every operation, thus compensating for the work entailed by the extra column.

In the plotting of the plan no difficulty is experienced, as it is manifest that a plan can be plotted to any desired scale, no matter what unit be used for the field measurements.

This is the system adopted in the sample of the field book in Appendix No. I. and used for making the plan shown on Fig. 15.

(b) To mark the staff in divisions equal to 0·02 of 10 feet (2·4 inches). These can be subdivided according to the ideas of the operator, or when reading he can judge of the subdivisions corresponding to 1 foot.

At any rate, whatever unit or constant be used, the graduations must always be bold enough not to cripple the power of the telescope.

FIELD WORK.

ALTHOUGH in every sense a universal instrument, yet as the chief utility of the tachéometer^{*} lies essentially in the execution of those preliminary topographical surveys required in connection with projected public works, more especially ways of communication, the following explanations will refer principally to this use.

The survey party ought to consist of an engineer in charge, who directs the whole operations, but more particularly the location of the staffmen, one assistant for working the instrument, another for booking the readings, and as many staffmen as the expertness of the various operators may necessitate.

The survey will be a traverse along the route selected by the engineer in charge, and all the main features of the country must be represented, such as roads, streams, rivers, buildings, boundaries of townships, etc. It will also be necessary to pick up all those prominent features required for laying down contours.

A start is made by finding the variation of the compass, an operation which ought always to be effected with care, and at stated intervals if the survey is long, although some engineers are inclined to neglect it.

In countries such as the British colonies, where reliable trigonometrical surveys exist, these can occasionally be joined on to and made to form not only the most satisfactory checks possible, but at the same time to provide a reliable orientation for the work in hand.

As a check on the levels it is advisable to run in a line of bench marks, or to find out the height of each traverse station by independent levelling.

If the latter system be adopted the check can only be effected as the survey advances, or when it is finished; but the former is usually sufficient, and in this case the bench marks ought to be put in ahead of the survey.

The field notes consist of two parts—

(a) A carefully made sketch of the ground showing the main survey lines, the various points picked up for laying down the contours and the other features already referred to. In many instances it is necessary to take subsidiary tape measurements to represent the details of buildings, or for any other reason; and in this case, these are also shown on this sketch. It is usually kept by the engineer in charge, and he must exercise extreme care in making his entries correspond exactly with those of the book used in connection with the instrument. The sketch is afterwards of the greatest use in the office for identifying details marked on the paper as the plotting advances.

Fig. 10 is a copy of the sketch made of a part of the ground represented in the plan on Fig. 15.

Some of the points have been suppressed for the sake of clearness.

(b) The field book kept by the assistant who enters the readings of the instrument. A sample page of this is given in Appendix No. I., and at least the first six columns are filled in on the ground. These are those headed Main Stations, Height of Instrument, Number of Point, Bearing, Vertical Angle, and Reading of Wires. Some operators endeavour to fill in the two columns headed Generating Number and Height on Staff; but this is better done in the office along with the remainder; for unless the assistant is very smart he will delay the whole party.

The traverse lines need not coincide exactly with what appears to be the proper alinement, although it is not advisable to separate from it to a very great extent. Special side stations may be used when it is required to see into a piece of ground not visible from the main traverse.

The instrument is set up at the intersections of all the lines, and these intersections form the principal stations.

The first work at a station is to measure the height of the main axis of the instrument above the station, entering it in the second column of the field book and on the line used for the designation of the station. For registering this height the units of measurement are used, not the divisions on the staves.

The next operation at a station is to find the

bearings of the two lines, the distance to the next station, and to check the distance to the last one.

The differences of level between them ought also to be checked; for although, as already mentioned, it is advisable to find the heights of the main stations independently, yet it is always well to bring on in the field a series of levels from station to station, as a reliable appreciation of the rate of the rise or fall of the country is thus gained.

The general principles applicable to all compass and traverse surveys hold good for taking the directions of the lines. The following explains the simplest way of proceeding.

Suppose the instrument set up at B , the intersection of two lines, AB and BC . By adding 180° to the forward bearing AB , found when the instrument was at A , we obtain the back bearing BA for the instrument at B . Clamp the horizontal vernier to this angle, turn round the whole instrument until the cross wires of the telescope cut the station A , fix the bottom clamp, and now the zero of the horizontal plate ought to correspond to the north. Unclamp the horizontal vernier plate, sight the forward station C , and the reading of the horizontal plate is the forward bearing BC .

As a check the needle itself may be slackened at occasional stations.

The distances and heights are checked by the application of Equations 4 and 5 to the readings of the wires and the angles read on the vertical arc. By taking more than one set of vertical angles and

readings of the wires, additional checks can be obtained for the same distances and heights, and if very particular work is desired, it is advisable to do this twice for each line converging at a station, thus obtaining four values, two from each end for the length of every line and the height between each station.

The calculation of these distances and heights must be done on the ground, so that any error may be found out and rectified at once.

The tables given in Appendices II. and III. will give the required reductions by a simple multiplication of the figures in the respective columns by the generating number, or logarithms may be used.

When readings in connection with any main traverse line are being observed, special care must be taken that the instrument is properly levelled up, that the staff is perfectly vertical, and that it is centred over the peg. Indeed, some engineers turn the staff edgewise when the observation for direction is being taken. It is only by attending to these details that high-class work can be attained, and as the time they occupy is inappreciable, there is no reason for neglecting them.

So that the nature of the checks required in the field may be perfectly understood, an example will now be given.

With a tacheometer whose constant is 0.02, let us suppose that a sight from a station, *A*, is taken to a staff on another station, *B*, that the bottom wire reads 50, the upper one 194, that the vertical angle is $90^{\circ} 46'$, and that the height of the instrument

above the station is 1.41 metre or yard, then the generating number (G) is $194 - 50 = 144$, and the height on the staff (m) struck by the central wire will be 2.44. See remark after Equation 7 (page 17).

Now by Equations $4a$ and $5a'$ we have for the horizontal distance D between the stations—

$$D = 144 \times \cos^2 0^\circ 46' = 143.96$$

and for the height II between the axis of the instrument and the point on the staff struck by the central line of sight of the telescope we get—

$$II = 143.96 \times \tan 0^\circ 46' = 1.93$$

But we are dealing with the case explained by Fig. 7, so the fall from the axis of the instrument at station A to the peg on which the staff rests at station B is $(II + m) = 1.93 + 2.44 = 4.37$. From this it is necessary to subtract the height of the instrument at A , and then we get $4.37 - 1.41 = 2.96$ as the resulting difference of height between the stations A and B .

When the instrument comes to be shifted to station B and directed to A , it is found that its height is 1.36, and that the vertical circle reads an angle of $88^\circ 34'$ when the wires read on the staff 30 and 174. In this case $G = 144$ and $m = 2.04$.

$$D = 144 \sin^2 88^\circ 34' = 143.91$$

$$II = 143.91 \cot 88^\circ 34' = 3.60$$

Or by using the tables in Appendix No. II. we find opposite $88^\circ 34'$, in the columns headed Distance and Difference in Height, 0.99938 and 0.02500

respectively, which multiplied by 144, the generating number, also give 143.91 for D and 3.60 for H .

Now, as the telescope points upwards, we have the case explained by Fig. 6, so there is a rise from the axis of the instrument at B to the station A equal to $H - m$ or $3.60 - 2.04 = 1.56$, and by allowing for the height of the instrument we get 2.92 as the difference of height between the stations.

Having now found two values for the horizontal distance and the height between the stations, the results may be compared thus—

Sight from	Hor. Dist.	Height.
A to B . . .	143.96 . . .	2.96
B to A . . .	143.91 . . .	2.92

These would be considered as agreeing sufficiently well, so their means would be adopted. However, should there result a divergence not within the limit of accuracy required for the survey, the instrument, still at B , must be re-levelled carefully, and other readings of the wires and the vertical angle taken and calculated out until no doubt exists as to the proper result. Although a written explanation of these checks seems lengthy, they take up very little time in reality and ought never to be omitted.

Having obtained all the data required in connection with the main lines, the topographical details are next taken. It is the engineer in charge who indicates to the staffmen, two to four in number, the sites where they must place the staves, and he continues to do so until these subsidiary points have

been taken all over the zone commanded from the main station at which the instrument is placed. He marks them all on his sketch, and it is he who is responsible for their giving an adequate representation of the country under survey.

The instrument assistant takes one by one the observations necessary for fixing these sites both in plan and in height, and reads them out aloud in the following order :—

- (1) The readings of the wires.
- (2) The vertical angle.
- (3) The bearing as shown on the horizontal plate.

It is convenient to direct the lower wire at an even number on the staff, and the assistant who enters the readings of the wires in the field book will take care to write the higher figure over the lower one. When the sight through one of the extreme wires aa' (Fig. 2) is intercepted by an obstacle, the reading of the other can be deduced from the central wire, or the fact that the central wire was read may be especially noted in the field book, say by a (c) written against its reading. When the extreme wires are both interrupted, then the other set, bb' , is used, taking care to mark this in the field book in a previously arranged manner. In these cases the generating number ought to be filled in at once.

Assume, for instance, that the wires bb' read 89 and 111 and the central wire 100, then the generating number to be entered is 110, that is five times the difference between 89 and 111, as the constant

corresponding to the wires aa' is five times that of the wires bb' which were read.

Sights are seldom required at greater distances than 200 or 250 yards; but when this becomes necessary and both extreme wires cannot be brought on the staff, use is made, as is in the case of interruptions, of the wires bb' (Fig. 2) or of the central wire, and an extreme one specially noticing this in the field book as formerly explained.

The booking assistant always remains close to the instrument and enters the observations as read out. He must satisfy himself that his designation of the different points is in accord with that which the chief of the party has adopted for his sketch. The main stations of the traverse may be indicated by letters and the points for filling in the details by numbers. The numbers may be used consecutively up to 100, 200, or further if there is a fear of their repetition in the same zone, and the letters all through the alphabet.

The staffmen must be smart and intelligent, but above everything they must understand the absolute necessity of holding the staff vertical. A suitable plumb-line ought to form part of their equipment, as it gives no trouble to carry about.

OFFICE WORK.

THE first work to be done in the office is to finish the reduction of the field book.

The column headed Generating Number or G consists simply of the difference between the readings of the two extreme wires; or, in the case of any of the other wires, of their difference manipulated so as to reduce it to that which would have been given by the extreme wires, had it been possible to use them.

The column headed Height on Staff or m consists of the solution of Equation 6, which is usually done by adding together the readings of the two wires and placing a decimal point in front of the second figure from the right-hand side.

The next two columns, headed respectively Horizontal Distance or D , and Difference in Height or H , are found by the solution of Equations 4, $4a$, 5, or $5a$, as the case may be. The operation of multiplying every generating number by the sine or cosine squared of the vertical angle, and this result by its cotangent or tangent, would be so tedious that the system of tacheometry would be of no practical value. To overcome this difficulty, the use of a slide rule was first suggested, and next,

tables were adopted. The former, without doubt, strains the eyes in an inordinate manner, whilst the latter are somewhat slow. Diagrams also were suggested, and even made; but none were really practical until Mr. Gustave Gillman, A.M.Inst.C.E., designed the one known by his name.* Its simplicity, the quickness with which expertness in its use is acquired, and the rapidity with which the results are obtained, place it far above any device hitherto adopted for effecting these reductions. Fig. 9 gives a reduction of the Gillman diagram. It consists essentially of a rectangle of quadriculated paper, the horizontal lines of which represent generating numbers, and the vertical lines the heights to be found. The scale of the vertical angle is marked off along its bottom and right-hand side, and the curves crossing the squares represent the amount to be subtracted from the generating numbers so as to give the horizontal distances. The thin silk thread attached at the upper left-hand corner is for application to the scale of angles.

The diagram is used thus: Lay it out flat on the drawing-table; with the right hand tighten the thread and apply it to that part of the scale representing the vertical angle being dealt with; observe or mark with a pricker held in the left hand the intersection of the thread and the horizontal line representing the generating number; then the vertical line which cuts this point of

intersection stands for the height; and the value of the nearest curve, or an interpolation between the two nearest ones, is the amount to be deducted from the generating number so as to obtain the horizontal distances. Let us take as an example a generating number of 111, with a vertical angle of $95^{\circ} 30'$, and refer to Fig. 9. It will be found that the thread when applied at $95^{\circ} 30'$ on the scale of angles intersects the horizontal line 111 just where this is crossed by the vertical line 10.6, and that this intersection coincides with the curve marked 1. Hence we make the difference in height H to be 10.6, and the horizontal distance D to be $(111 - 1)$ or 110. The use of logarithms or tables would have given 10.59 and 109.98 respectively, so the results found by the diagram are quite acceptable, as only the subsidiary points are calculated by it.

In using the Gillman diagram it is a great advantage for two assistants to work together; one reading from the field book and entering in it the results found by the other operating on the diagram.

When the columns of distances and differences of height are all filled in, the rises and falls are next entered up, and for fixing these, Figs. 6, 7, and 8 must be kept in mind. Another simple rule is to consider the height on the staff always a minus quantity, and the difference in height as a plus quantity if the telescope points upwards, or as a minus one if it points downwards. The algebraic result, if plus, is entered as a rise, and when minus, as a fall.

The reduced level of any point is found in the usual way by adding the rises to and subtracting the falls from the height of the instrument.

If the measurements have been carried out in yards, still another column must be filled in. This will be the height of the station or point multiplied by three, so as to give feet, the universal unit for expressing heights in British practice. This was the case with the survey shown in Fig. 15; but whenever possible it is advisable to adopt for the horizontal measurements the same unit as for the heights. With the metre this always occurs; consequently the extra column referred to is eliminated by its use.

The sample of a field book given in Appendix No. I. shows exactly how these reductions are made, and it will be seen that the work entailed by them is very little more troublesome than that of an ordinary level book.

The plotting of the plan is next undertaken, and when determining the scale it must be remembered that the operations carried out in the field have been intended only for preliminary studies, so a large scale would be out of place. On a plan drawn to a scale of 3 chains, or about 200 feet to an inch, the limit of error is quite inappreciable, and this may be taken as the largest advisable; whilst the smallest desirable for showing public works is perhaps 6 chains, or say 400 feet to an inch. These limits in metrical arrangements are nearly enough represented by scales of $\frac{1}{2500}$ and $\frac{1}{5000}$ respectively.

Having fixed on the general direction to be taken by the plan along the roll of paper, north and south lines are laid on it at a series of convenient places, and the main traverse lines are plotted with a parallel ruler in the usual way. Rectangular co-ordinates may be used; but the extra work entailed is not usually compensated for by a notably extra degree of correctness.

After laying down the main lines, the details can be plotted at each station by means of radiating lines representing the directions and distances to the points where the staves have been placed; but the protractor shown in Fig. 11 has been designed to prevent the ugly scoring of radiating pencil lines. It may be made of vulcanite, cardboard, or any suitable material, and is semicircular. The figuring of the degrees round the circumference is such that they read from right to left, one set 0° to 180° and the other 180° to 360° . A convenient size is 9 inches in diameter. It has the scale of the plan doubly marked along its diameter, once to the right of the centre and once to the left of the centre, the zero of each corresponding to the centre itself.

To use this protractor a needle is passed through its centre, and at the same time through the station, as marked on the paper.

It is then rotated until the bearing of the point to be fixed is read on a north line drawn through the station, when the diameter will represent the direction to the point in question.

The distance is next marked off by means of

the corresponding scale ; that to the right of the centre being used when the bearing is between 0° and 180° , and that to the left when it is between 180° and 360° . Against the point just marked on the plan its reduced level is written.

In this manner all the details taken in the field are put on the plan, use being also made of the independent notes and small measurements taken by the engineer in charge of the field work. The sketch, Fig. 10, will now be found to be of the greatest use in running in the various streams, roads, etc., between the points which determine their directions and courses. Besides these, the plan will be studded with dots showing the levels and positions of the culminating points, taken for the purpose of representing the natural outlines of the ground. When a sufficient portion of the plan is thus prepared in pencil, its inking in is proceeded with, all points being marked by a firm dot against which their levels are written.

By means of these levels, contour lines are next traced, which in height may be separated from one another 2 to 5 metres, or 5, 10, or 20 feet, according to the roughness of the ground.

The simple device shown in Fig. 12 has to a large extent done away with the tediousness of marking off contours. This diagram is marked off on tracing paper, its construction being evident from an examination of the figure. The parallel lines a, a, a , crossing the radial ones, act simply as guides in adjusting the diagram to the two

points between which contours have to be marked.

Let us suppose that contour lines are being delineated for every 5 feet on a plan of 200 feet = 1 inch, and that it is desired to mark those that pass between two points, x and y , 380 feet apart, whose heights are respectively 81 and 107 feet above datum.

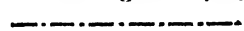

It will be observed that every fifth radial line is alternately red and blue. Assuming in the present instance that the bottom outside red line represents 80, the first blue line will represent 85, the next red one 90, the next blue one 95, and so on.*

Now make the station (x) coincide with any part of the line (81) that is the one next that standing for 80, then run that line over the point until the line corresponding to 107 coincides with the point (y), always taking care that the line between the points themselves is parallel to the lines a, a, a .

Prick through on the red and blue lines which occur between the stations x and y , and in this case these will give the contours for 85, 90, 95, 100, and 105.

Similarly the spots are pricked off where the contours pass between the adjacent points marked on the plan.

If the points are near to one another it is manifest that the consecutive radial lines, and not every fifth one, may be made to represent the consecutive

* In the illustration here given (Fig. 12), the lines that should be red are shown thus:  and those that should be blue, thus: 

contours by a suitable interpolation of the heights of the points.

Pencil lines are next drawn between the pricks or marks designating each contour, and a continuation of this operation all over the plan furnishes the contour lines required.

They are usually inked in in burnt sienna, every fifth one being made much stouter than the others.

Occasionally, and at convenient places, the heights shown by the contour lines are written against them in the same colour as is used for inking them in.

This practically finishes the plan, and we shall now have before us a genuine representation of the country which it is intended to deal with, so that after a few trials a centre line can be laid down which will require no further alteration. For tracing it on the ground in the definite setting out, the main stations of the survey are used as reference points; so they must be carefully marked and preserved on the ground.

Trial longitudinal sections and cross sections can be made from the plan, and the results of the cubications ought to vary but little from the definite quantities eventually found by means of the working plans.

Fig. 15 shows a plan made from a tacheometer survey with a trace for part of a narrow-gauge railway on it; whilst Fig. 13 is the trial longitudinal section along the centre line selected. On the plan a partially alternative line is shown in dots, having

curves of sharper radius and with less length of straight between reverse curves. A section taken along this, which may be called a second-class location, will show a diminution in earthwork.

To those engineers who deal with rough and unknown countries abroad, or who have to study the location of new or branch railways at home, the system of surveying now described supplies a want that was beyond doubt largely felt; whilst for all general purposes both engineers and surveyors will find it of universal application.

OTHER METHODS OF TACHEOMETRY.

SOME surveyors introduce extra wires in the telescopes of their transit theodolites, but as a rule these telescopes are deficient in power for use as tacheometers.

Another objection to them is that in this case the apex of the "measuring angle" is formed, not at the axis of the instrument, but at a distance beyond the object-glass equal to its focal length; so that to obtain suitable results, especially when levels are being determined, it is necessary to make an allowance for the distance between the exterior focus of the object-glass and the axis of the instrument. This allowance can be made by adding a constant to the generating numbers ($1\frac{1}{2}$ to 2 ft., according to the build of the instrument), and the results will then approximate sufficiently well to reality for practical uses; so that all the explanations of the processes of field work and plotting the plan given in the foregoing pages will hold good.

This method ought only to be thought of when it is necessary to utilize a theodolite already possessed, and when the amount of the work to be undertaken will not justify the expense of a new instrument.

Finally we will notice a system which not only seems capable of great adaptability, but as it does away with the use of all tables or diagrams for

calculating the reductions, these become so simple that this advantage alone will go far to compensate for any other defects, should such be encountered. It is believed to have been first of all pointed out by Barcenas, a Spanish writer on tacheometry; but so far as can be found out it has not received much, if any, attention.

It may be called the "Tangential" system, and consists in directing at a staff the telescope of an ordinary theodolite set consecutively at any two adjoining angles amongst those whose tangents are: 0.01, 0.02, 0.03, 0.04, 0.05, etc.

A system of tacheometry based upon the tangents of the angles subtended by a known length of staff has long been before engineers; but the method now to be described varies from this, consisting, as it does, in the observation of a variable length on the staff by placing the telescope at two definite angles. In fact, the former may be said to depend on the observation of a constant height on the staff and variable angles on the instrument; whilst the latter depends on the observation of a variable height on the staff and fixed angles on the instrument.

This table explains the angles referred to:—

Angles.			Tangents.
Degrees.	Minutes.	Seconds.	
0	34	23	0.01
1	8	54	0.02
1	43	6	0.03
2	17	36	0.04
2	51	45	0.05
3	26	1	0.06

And so on,

Now let Fig. 14 represent the foregoing series of angles as marked on the vertical circle of a theodolite placed at O , whose telescope is directed at a staff, held vertically at AB and marked with the units of measurement being used. Oa is the horizontal line through the instrument striking the staff at a .

It will be observed that this series of tangents is such that the difference between those of adjoining angles is always 0.01. Take any two adjacent vertical angles, say those whose tangents are 0.03 and 0.04 and which strike the staff at x and y respectively. Let the distance which would be read between x and y be called G , and let the horizontal distance Oa from the instrument to the staff be D .

$$\text{Now } ay = 0.04 \ D$$

$$\text{and } ax = 0.03 \ D$$

$$\text{hence } (ay - ax) \text{ or } G = \underline{0.01 \ D}$$

and as this results from any adjacent angles that may be used we have the general rule—

$$D = 100 \ G$$

which shows that the space read on the staff multiplied by 100 gives the horizontal distance at once, so that this operation consisting of running the decimal point two places to the right is simplicity itself.

The height between the instrument and either point struck on the staff is the horizontal distance multiplied by the corresponding tangent, and as these

tangents consist of simple figures, this operation can nearly always be done by inspection.

These are all the calculations necessary; no tables, no diagram, no slide rule, in fact no accessory of any sort, is required. Such simplicity cannot be surpassed.

It will, however, be observed that a theodolite adapted for this work ought to be fitted with a suitable scale on the vertical circle, as well as an extra zero arm and microscope.

An examination similar to that adopted in connection with Figs. 6, 7, and 8 will show that the rises and falls between the instrument and the ground at the staff are given by the following formulæ in which—

D stands for the horizontal distance.

r „ „ the tangent of the smaller angle.

m „ „ the height read on the staff when
the telescope points at the
smaller angle.

T „ „ the rise or fall.

(i) *When the telescope is pointing upwards, the rise is given by—*

$$T = Dr - m$$

But should the result give a minus sign, it is an indication that there is really a fall, as in Fig. 8.

(ii) *When the telescope points downwards, the fall between the instrument and the ground at the staff is—*

$$T = Dr + m$$

42 SURVEYING WITH THE TACHEOMETER.

The following form of field book has been suggested:—

Stations.	Height of Instrument.	No. of Point.	Bearing.	Tangents.		Staff Readings.	Horizontal Distance.	Height.	Rise.	Fall.	Red. level of Instrument.	Red. level of Point.	Observations.
				Up	Down								
				+	-		D	D × r	+ Dr - m	- Dr + m			
A	1.45										69.25	67.80	
		1	343° 9'	0.05 0.04		1.36 0.42	94	3.76	3.34			72.59	
		2	140° 13'		0.06 0.07	2.47 1.82	65	3.90		6.37		62.88	

The operations in the field and the plotting of the plan would be conducted in exactly the same manner as already explained when treating of the usual system of tacheometry.

APPENDIX No. I.



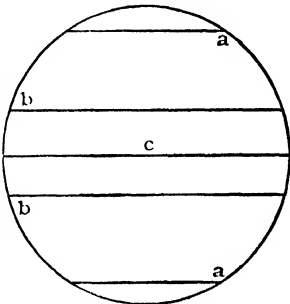
SAMPLE OF FIELD BOOK.

Survey.

STATIONS.	Height of Instru- ment.	No. of Point.	Bearing.		Vertical Angle.		Reading of Wires.	Gene- rating Number.	Height on Staff.	Horizontal Distance.
										$G \sin^2 V$
			D							
			Deg.	Min.	Deg.	Min.		G	m	D
									—	
A	1.56									
		B	157	0	92	5	185(c) 30	310	3.70	309.59
		B	157	0	91	58½	215(c) 60	310	4.30	309.63
		201	68	52	102	19	110 10	100	1.20	95.5
		209	92	14	87	48	178(b) 132(b)	230	3.10	229.7
		211	101	53	85	17	188(c) 50	276	3.76	274.1
		216	72	32	108	17	132 60	72	1.92	65.0
		218	135	55	112	18	159 90	69	2.49	59.0
		222	161	47	103	23	198 90	108	2.88	102.3
		230	100	0	92	33	161 10	151	1.71	150.7
		231	103	36	92	26	161 20	141	1.81	140.7
		27	176	23	89	56	207(c) 70	274	4.14	274.0
B	1.15		Adopt from A to B						-----	309.62
		A	337	0	87	0	155(c) 39½	310½	3.90	309.65
		C	158	13	92	37	211 40	171	2.51	170.64

* See Fig. 6.

† See Fig. 7.

Difference in Height.	Rise.		Reduced Levels.			REMARKS.
	D cot V	m + II or m - H	Axis of Instrument.	Point or Station.	Feet.	
H	+	-				
			486.08	484.52	1453.56	
11.26		14.96				+ 1.56 - 14.96 = - 13.40
10.69		14.99				+ 1.56 - 14.99 = - 13.43
20.8		22.0		464.08	1392.24	$\begin{aligned} c a &= .01 \\ a a &= .02 \\ b b &= .004 \end{aligned}$ 
8.8	5.70*			491.78	1475.34	
22.6	18.84			504.92	1514.76	
21.3		23.22†		462.86	1388.58	
24.2		26.69		459.39	1378.17	
24.2		27.08		459.00	1377.00	Staff divisions = 0.02 yd.
6.7		8.41		477.67	1433.01	Corner of hut.
6.0		7.81		478.27	1434.81	Corner of hut.
0.4		3.74‡		482.34	1447.02	
		13.45	472.22	471.07	1413.21	484.52 - 13.45 = 471.07
16.24	12.34					+ 1.15 + 12.34 = + 13.49
7.80		10.31				+ 1.15 - 10.31 = - 8.91

† See Fig. 8.

APPENDIX No. II.

TABLE FOR REDUCING DISTANCES AND HEIGHTS (ORDINARY DEGREES).

To find the distance or difference in height, multiply the numbers corresponding to the vertical angles in the respective columns by the generating number.

90 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	1.00000	.00000	60	30	.99992	.00873	30
1	1.00000	.00029	59	31	.99992	.00902	29
2	1.00000	.00058	58	32	.99991	.00931	28
3	1.00000	.00087	57	33	.99991	.00960	27
4	1.00000	.00116	56	34	.99990	.00989	26
5	.99999	.00145	55	35	.99990	.01018	25
6	.99999	.00175	54	36	.99989	.01047	24
7	.99999	.00204	53	37	.99988	.01076	23
8	.99999	.00233	52	38	.99988	.01105	22
9	.99999	.00262	51	39	.99987	.01134	21
10	.99999	.00291	50	40	.99986	.01164	20
11	.99999	.00320	49	41	.99986	.01193	19
12	.99999	.00349	48	42	.99985	.01222	18
13	.99999	.00378	47	43	.99984	.01251	17
14	.99999	.00407	46	44	.99984	.01280	16
15	.99998	.00436	45	45	.99983	.01309	15
16	.99998	.00465	44	46	.99983	.01338	14
17	.99998	.00495	43	47	.99982	.01367	13
18	.99997	.00524	42	48	.99981	.01396	12
19	.99997	.00553	41	49	.99980	.01425	11
20	.99996	.00582	40	50	.99979	.01454	10
21	.99996	.00611	39	51	.99978	.01483	9
22	.99996	.00640	38	52	.99977	.01513	8
23	.99996	.00669	37	53	.99976	.01542	7
24	.99995	.00698	36	54	.99975	.01571	6
25	.99995	.00727	35	55	.99974	.01600	5
26	.99994	.00756	34	56	.99973	.01629	4
27	.99994	.00785	33	57	.99972	.01658	3
28	.99993	.00814	32	58	.99971	.01687	2
29	.99993	.00844	31	59	.99970	.01715	1
30	.99992	.00873	30	60	.99969	.01745	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

89 Deg.

91 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·99969	·01745	60	30	·99931	·02617	30
1	·99963	·01774	59	31	·99930	·02646	29
2	·99967	·01803	58	32	·99929	·02675	28
3	·99966	·01832	57	33	·99927	·02704	27
4	·99965	·01862	56	34	·99926	·02733	26
5	·99964	·01891	55	35	·99924	·02762	25
6	·99963	·01920	54	36	·99923	·02791	24
7	·99962	·01949	53	37	·99921	·02820	23
8	·99961	·01978	52	38	·99919	·02850	22
9	·99960	·02007	51	39	·99917	·02878	21
10	·99959	·02036	50	40	·99915	·02907	20
11	·99957	·02065	49	41	·99914	·02937	19
12	·99956	·02094	48	42	·99912	·02966	18
13	·99954	·02123	47	43	·99910	·02995	17
14	·99953	·02152	46	44	·99909	·03024	16
15	·99952	·02180	45	45	·99907	·03053	15
16	·99950	·02210	44	46	·99906	·03082	14
17	·99949	·02239	43	47	·99904	·03111	13
18	·99948	·02268	42	48	·99902	·03139	12
19	·99947	·02297	41	49	·99900	·03168	11
20	·99946	·02326	40	50	·99898	·03197	10
21	·99944	·02355	39	51	·99896	·03226	9
22	·99943	·02384	38	52	·99894	·03255	8
23	·99942	·02413	37	53	·99892	·03284	7
24	·99941	·02442	36	54	·99890	·03314	6
25	·99939	·02471	35	55	·99888	·03343	5
26	·99938	·02500	34	56	·99886	·03372	4
27	·99937	·02530	33	57	·99884	·03401	3
28	·99935	·02559	32	58	·99882	·03430	2
29	·99933	·02588	31	59	·99880	·03459	1
30	·99931	·02617	30	60	·99878	·03488	0
	Distance.	Difference in Height.	Minutes		Distance.	Difference in Height.	Minutes.

88 Deg.

92 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·99878	·03488	60	30	·99810	·04358	30
1	·99876	·03517	59	31	·99808	·04387	29
2	·99874	·03546	58	32	·99805	·04416	28
3	·99872	·03575	57	33	·99803	·04445	27
4	·99870	·03604	56	34	·99800	·04474	26
5	·99868	·03633	55	35	·99797	·04502	25
6	·99866	·03662	54	36	·99795	·04531	24
7	·99864	·03690	53	37	·99792	·04560	23
8	·99862	·03720	52	38	·99789	·04589	22
9	·99860	·03749	51	39	·99787	·04618	21
10	·99857	·03778	50	40	·99784	·04648	20
11	·99855	·03807	49	41	·99781	·04677	19
12	·99853	·03836	48	42	·99778	·04706	18
13	·99851	·03865	47	43	·99775	·04735	17
14	·99849	·03894	46	44	·99772	·04764	16
15	·99846	·03923	45	45	·99769	·04792	15
16	·99844	·03952	44	46	·99767	·04821	14
17	·99841	·03981	43	47	·99764	·04850	13
18	·99839	·04010	42	48	·99762	·04870	12
19	·99837	·04039	41	49	·99759	·04908	11
20	·99834	·04068	40	50	·99756	·04937	10
21	·99832	·04097	39	51	·99753	·04966	9
22	·99829	·04125	38	52	·99750	·04995	8
23	·99827	·04155	37	53	·99747	·05024	7
24	·99825	·04184	36	54	·99744	·05053	6
25	·99822	·04213	35	55	·99741	·05081	5
26	·99820	·04242	34	56	·99738	·05110	4
27	·99818	·04271	33	57	·99735	·05139	3
28	·99815	·04300	32	58	·99732	·05169	2
29	·99813	·04329	31	59	·99729	·05198	1
30	·99810	·04358	30	60	·99726	·05227	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

87 Deg.

98 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·99726	·05227	60	30	·99627	·06094	30
1	·99723	·05256	59	31	·99624	·06123	29
2	·99720	·05285	58	32	·99620	·06151	28
3	·99717	·05314	57	33	·99617	·06180	27
4	·99714	·05342	56	34	·99613	·06209	26
5	·99711	·05371	55	35	·99609	·06238	25
6	·99708	·05400	54	36	·99606	·06267	24
7	·99705	·05429	53	37	·99602	·06288	23
8	·99702	·05458	52	38	·99599	·06324	22
9	·99699	·05487	51	39	·99595	·06353	21
10	·99695	·05516	50	40	·99591	·06382	20
11	·99692	·05544	49	41	·99587	·06411	19
12	·99689	·05573	48	42	·99583	·06440	18
13	·99686	·05602	47	43	·99579	·06468	17
14	·99683	·05631	46	44	·99575	·06497	16
15	·99679	·05660	45	45	·99572	·06526	15
16	·99676	·05689	44	46	·99568	·06555	14
17	·99673	·05718	43	47	·99564	·06584	13
18	·99669	·05746	42	48	·99560	·06612	12
19	·99666	·05775	41	49	·99556	·06641	11
20	·99662	·05804	40	50	·99553	·06670	10
21	·99659	·05834	39	51	·99549	·06699	9
22	·99656	·05863	38	52	·99545	·06728	8
23	·99652	·05892	37	53	·99541	·06757	7
24	·99649	·05921	36	54	·99537	·06786	6
25	·99645	·05949	35	55	·99533	·06815	5
26	·99642	·05978	34	56	·99529	·06844	4
27	·99638	·06007	33	57	·99525	·06873	3
28	·99635	·06036	32	58	·99521	·06901	2
29	·99631	·06065	31	59	·99517	·06930	1
30	·99627	·06094	30	60	·99513	·06959	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

86 Deg.

94 Deg.

Minutes.	Distance.	Difference in Height.		Minutes	Distance.	Difference in Height.	
0	·99513	·06959	60	30	·99384	·07822	30
1	·99509	·06988	59	31	·99380	·07851	29
2	·99505	·07017	58	32	·99375	·07879	28
3	·99501	·07045	57	33	·99371	·07906	27
4	·99497	·07074	56	34	·99366	·07937	26
5	·99493	·07103	55	35	·99361	·07965	25
6	·99489	·07132	54	36	·99357	·07994	24
7	·99485	·07160	53	37	·99352	·08023	23
8	·99481	·07219	52	38	·99348	·08052	22
9	·99477	·07218	51	39	·99343	·08080	21
10	·99472	·07247	50	40	·99338	·08109	20
11	·99468	·07276	49	41	·99333	·08138	19
12	·99464	·07215	48	42	·99328	·08166	18
13	·99460	·07333	47	43	·99323	·08195	17
14	·99456	·07362	46	44	·99318	·08224	16
15	·99451	·07391	45	45	·99314	·08253	15
16	·99447	·07419	44	46	·99309	·08281	14
17	·99443	·07448	43	47	·99304	·08310	13
18	·99438	·07477	42	48	·99299	·08339	12
19	·99434	·07506	41	49	·99294	·08367	11
20	·99429	·07534	40	50	·99290	·08396	10
21	·99425	·07563	39	51	·99285	·08425	9
22	·99421	·07592	38	52	·99280	·08453	8
23	·99416	·07621	37	53	·99275	·08482	7
24	·99412	·07649	36	54	·99270	·08511	6
25	·99407	·07678	35	55	·99265	·08539	5
26	·99402	·07707	34	56	·99260	·08568	4
27	·99398	·07736	33	57	·99255	·08597	3
28	·99393	·07764	32	58	·99250	·08626	2
29	·99389	·07793	31	59	·99245	·08654	1
30	·99384	·07822	30	60	·99240	·08683	0
	Distance.	Difference in Height.	Minutes		Distance.	Difference in Height.	Minutes.

86 Deg.

APPENDIX II.

95 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·99240	·08683	60	30	·99081	·09541	30
1	·99235	·08712	59	31	·99076	·09569	29
2	·99230	·08740	58	32	·99070	·09597	28
3	·99225	·08769	57	33	·99065	·09626	27
4	·99220	·08796	56	34	·99059	·09654	26
5	·99215	·08825	55	35	·99053	·09683	25
6	·99210	·08854	54	36	·99048	·09711	24
7	·99205	·08883	53	37	·99042	·09740	23
8	·99200	·08911	52	38	·99037	·09769	22
9	·99195	·08940	51	39	·99031	·09797	21
10	·99189	·08968	50	40	·99025	·09826	20
11	·99184	·08997	49	41	·99019	·09854	19
12	·99179	·09026	48	42	·99014	·09883	18
13	·99174	·09054	47	43	·99008	·09911	17
14	·99169	·09083	46	44	·99002	·09940	16
15	·99163	·09112	45	45	·98996	·09969	15
16	·99158	·09040	44	46	·98990	·09997	14
17	·99153	·09169	43	47	·98984	·10026	13
18	·99147	·09197	42	48	·98979	·10054	12
19	·99142	·09226	41	49	·98973	·10083	11
20	·99136	·09255	40	50	·98967	·10111	10
21	·99131	·09283	39	51	·98961	·10139	9
22	·99126	·09312	38	52	·98955	·10167	8
23	·99120	·09341	37	53	·98949	·10196	7
24	·99115	·09369	36	54	·98943	·10225	6
25	·99109	·09398	35	55	·98937	·10253	5
26	·99104	·09426	34	56	·98931	·10282	4
27	·99098	·09455	33	57	·98925	·10310	3
28	·99092	·09484	32	58	·98919	·10339	2
29	·99087	·09512	31	59	·98913	·10367	1
30	·99081	·09541	30	60	·98907	·10396	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

84 Deg.

APPENDIX II.

55

96 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·98907	·10396	60	30	·98718	·11247	30
1	·98901	·10424	59	31	·98712	·11276	29
2	·98895	·10453	58	32	·98706	·11304	28
3	·98889	·10481	57	33	·98699	·11333	27
4	·98883	·10510	56	34	·98693	·11361	26
5	·98877	·10537	55	35	·98686	·11389	25
6	·98871	·10566	54	36	·98680	·11418	24
7	·98865	·10594	53	37	·98673	·11446	23
8	·98859	·10623	52	38	·98666	·11475	22
9	·98853	·10651	51	39	·98659	·11502	21
10	·98846	·10680	50	40	·98652	·11531	20
11	·98840	·10708	49	41	·98645	·11559	19
12	·98834	·10737	48	42	·98639	·11587	18
13	·98828	·10765	47	43	·98632	·11616	17
14	·98822	·10794	46	44	·98625	·11644	16
15	·98815	·10822	45	45	·98618	·11673	15
16	·98809	·10851	44	46	·98611	·11701	14
17	·98802	·10879	43	47	·98604	·11729	13
18	·98796	·10907	42	48	·98598	·11757	12
19	·98790	·10935	41	49	·98591	·11785	11
20	·98783	·10964	40	50	·98584	·11814	10
21	·98777	·10992	39	51	·98577	·11842	9
22	·98770	·11021	38	52	·98570	·11870	8
23	·98764	·11049	37	53	·98563	·11899	7
24	·98758	·11078	36	54	·98557	·11927	6
25	·98751	·11106	35	55	·98550	·11955	5
26	·98745	·11134	34	56	·98543	·11983	4
27	·98738	·11163	33	57	·98536	·12011	3
28	·98732	·11191	32	58	·98529	·12039	2
29	·98725	·11219	31	59	·98522	·12068	1
30	·98718	·11247	30	60	·98515	·12096	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

83 Deg.

97 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·98515	·12096	60	30	·98296	·12941	30
1	·98508	·12125	59	31	·98289	·12969	29
2	·98501	·12153	58	32	·98281	·12997	28
3	·98494	·12181	57	33	·98273	·13025	27
4	·98487	·12209	56	34	·98266	·13053	26
5	·98479	·12237	55	35	·98258	·13082	25
6	·98472	·12265	54	36	·98251	·13110	24
7	·98465	·12294	53	37	·98243	·13137	23
8	·98458	·12322	52	38	·98235	·13165	22
9	·98451	·12350	51	39	·98228	·13194	21
10	·98443	·12379	50	40	·98220	·13222	20
11	·98436	·12406	49	41	·98213	·13250	19
12	·98429	·12434	48	42	·98205	·13278	18
13	·98422	·12463	47	43	·98197	·13305	17
14	·98415	·12491	46	44	·98189	·13334	16
15	·98407	·12519	45	45	·98181	·13362	15
16	·98400	·12547	44	46	·98174	·13390	14
17	·98393	·12576	43	47	·98166	·13418	13
18	·98386	·12603	42	48	·98158	·13446	12
19	·98379	·12631	41	49	·98150	·13474	11
20	·98371	·12660	40	50	·98142	·13502	10
21	·98363	·12688	39	51	·98135	·13530	9
22	·98356	·12716	38	52	·98127	·13558	8
23	·98349	·12744	37	53	·98119	·13586	7
24	·98342	·12773	36	54	·98111	·13614	6
25	·98334	·12780	35	55	·98103	·13642	5
26	·98327	·12828	34	56	·98095	·13670	4
27	·98319	·12857	33	57	·98087	·13698	3
28	·98312	·12885	32	58	·98079	·13726	2
29	·98304	·12913	31	59	·98071	·13754	1
30	·98296	·12941	30	60	·98063	·13782	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

82 Deg.

98 Deg.

Minutes	Distance.	Difference in Height.		Minutes	Distance.	Difference in Height.	
0	·98063	·13782	60	30	·97815	·14619	30
1	·98055	·13810	59	31	·97807	·14647	29
2	·98047	·13838	58	32	·97798	·14674	28
3	·98039	·13866	57	33	·97789	·14702	27
4	·98031	·13895	56	34	·97781	·14730	26
5	·98023	·13921	55	35	·97772	·14758	25
6	·98015	·13949	54	36	·97763	·14786	24
7	·98007	·13978	53	37	·97755	·14813	23
8	·97999	·14006	52	38	·97746	·14841	22
9	·97991	·14034	51	39	·97737	·14869	21
10	·97982	14061	50	40	·97729	·14897	20
11	·97974	·14089	49	41	·97720	·14924	19
12	·97966	·14117	48	42	·97711	·14952	18
13	·97958	·14145	47	43	·97703	·14980	17
14	·97950	·14172	46	44	·97695	·15008	16
15	·97941	·14200	45	45	·97686	·15035	15
16	·97933	·14229	44	46	·97678	·15063	14
17	·97924	·14257	43	47	·97669	·15091	13
18	·97916	·14285	42	48	·97660	·15119	12
19	·97908	·14312	41	49	·97651	·15146	11
20	·97899	·14340	40	50	·97642	·15174	10
21	·97891	·14368	39	51	·97633	·15202	9
22	·97883	·14396	38	52	·97625	·15230	8
23	·97875	·14424	37	53	·97616	·15257	7
24	·97867	·14451	36	54	·97607	·15285	6
25	·97858	·14479	35	55	·97598	·15313	5
26	·97849	·14507	34	56	·97589	·15341	4
27	·97841	·14535	33	57	·97580	·15368	3
28	·97832	·14563	32	58	·97571	·15396	2
29	·97824	·14591	31	59	·97562	·15423	1
30	·97815	·14619	30	60	·97553	·15450	0
	Distance.	Difference in Height.	Minutes		Distance.	Difference in Height.	Minutes.

81 Deg.

99 Deg.

Minutes.	Distance.	Difference in Height.		Minutes	Distance.	Difference in Height.	
0	·97553	·15450	60	30	·97276	·16279	30
1	·97544	·15478	59	31	·97266	·16306	29
2	·97535	·15506	58	32	·97257	·16333	28
3	·97526	·15534	57	33	·97247	·16361	27
4	·97517	·15562	56	34	·97238	·16389	26
5	·97508	·15589	55	35	·97229	·16416	25
6	·97499	·15617	54	36	·97219	·16444	24
7	·97490	·15645	53	37	·97209	·16471	23
8	·97481	·15672	52	38	·97200	·16498	22
9	·97472	·15700	51	39	·97190	·16526	21
10	·97462	·15728	50	40	·97180	·16554	20
11	·97453	·15754	49	41	·97171	·16580	19
12	·97444	·15782	48	42	·97161	·16608	18
13	·97435	·15810	47	43	·97151	·16636	17
14	·97426	·15838	46	44	·97142	·16663	16
15	·97416	·15865	45	45	·97132	·16690	15
16	·97407	·15893	44	46	·97123	·16718	14
17	·97398	·15921	43	47	·97113	·16745	13
18	·97389	·15948	42	48	·97103	·16773	12
19	·97380	·15975	41	49	·97093	·16800	11
20	·97370	·16003	40	50	·97083	·16827	10
21	·97361	·16031	39	51	·97073	·16855	9
22	·97352	·16058	38	52	·97064	·16883	8
23	·97343	·16086	37	53	·97054	·16909	7
24	·97334	·16114	36	54	·97044	·16937	6
25	·97325	·16140	35	55	·97034	·16965	5
26	·97315	·16168	34	56	·97024	·16991	4
27	·97305	·16196	33	57	·97014	·17028	3
28	·97295	·16223	32	58	·97005	·17047	2
29	·97285	·16251	31	59	·96995	·17074	1
30	·97276	·16279	30	60	·96985	·17101	0
	Distance.	Difference in Height.	Minutes		Distance.	Difference in Height.	Minutes.

80 Deg.

APPENDIX II.

59

100 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	•96985	•17101	60	30	•96679	•17919	30
1	•96975	•17128	59	31	•96669	•17945	29
2	•96965	•17156	58	32	•96658	•17973	28
3	•96955	•17183	57	33	•96648	•18000	27
4	•96945	•17210	56	34	•96637	•18027	26
5	•96935	•17238	55	35	•96627	•18055	25
6	•96925	•17265	54	36	•96616	•18081	24
7	•96915	•17292	53	37	•96606	•18109	23
8	•96905	•17320	52	38	•96595	•18135	22
9	•96894	•17347	51	39	•96585	•18163	21
10	•96884	•17374	50	40	•96574	•18189	20
11	•96874	•17402	49	41	•96564	•18217	19
12	•96864	•17428	48	42	•96553	•18244	18
13	•96854	•17456	47	43	•96542	•18271	17
14	•96844	•17483	46	44	•96532	•18298	16
15	•96834	•17510	45	45	•96521	•18325	15
16	•96823	•17538	44	46	•96510	•18352	14
17	•96813	•17565	43	47	•96499	•18380	13
18	•96803	•17592	42	48	•96488	•18406	12
19	•96793	•17619	41	49	•96477	•18434	11
20	•96782	•17646	40	50	•96467	•18460	10
21	•96772	•17674	39	51	•96456	•18487	9
22	•96762	•17701	38	52	•96445	•18514	8
23	•96751	•17728	37	53	•96434	•18541	7
24	•96741	•17755	36	54	•96424	•18569	6
25	•96731	•17783	35	55	•96413	•18595	5
26	•96720	•17810	34	56	•96402	•18623	4
27	•96710	•17837	33	57	•96391	•18649	3
28	•96700	•17864	32	58	•96381	•18676	2
29	•96690	•17891	31	59	•96370	•18703	1
30	•96679	•17919	30	60	•96359	•18730	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

79 Deg.

101 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·96359	·18730	60	30	·96025	·19537	30
1	·96348	·18757	59	31	·96013	·19563	29
2	·96337	·18784	58	32	·96002	·19590	28
3	·96326	·18812	57	33	·95990	·19617	27
4	·96315	·18838	56	34	·95979	·19644	26
5	·96304	·18865	55	35	·95968	·19670	25
6	·96293	·18892	54	36	·95956	·19697	24
7	·96282	·18919	53	37	·95945	·19724	23
8	·96271	·18946	52	38	·95934	·19751	22
9	·96260	·18973	51	39	·95922	·19770	21
10	·96249	·18999	50	40	·95911	·19804	20
11	·96238	·19027	49	41	·95899	·19830	19
12	·96227	·19053	48	42	·95888	·19858	18
13	·96216	·19080	47	43	·95876	·19884	17
14	·96205	·19108	46	44	·95865	·19911	16
15	·96194	·19134	45	45	·95853	·19937	15
16	·96182	·19162	44	46	·95842	·19965	14
17	·96171	·19188	43	47	·95830	·19991	13
18	·96160	·19215	42	48	·95818	·20018	12
19	·96149	·19242	41	49	·95807	·20044	11
20	·96138	·19269	40	50	·95795	·20071	10
21	·96126	·19295	39	51	·95783	·20097	9
22	·96115	·19322	38	52	·95771	·20124	8
23	·96104	·19349	37	53	·95759	·20151	7
24	·96093	·19376	36	54	·95747	·20177	6
25	·96082	·19402	35	55	·95736	·20204	5
26	·96071	·19430	34	56	·95725	·20230	4
27	·96059	·19456	33	57	·95713	·20257	3
28	·96048	·19483	32	58	·95701	·20283	2
29	·96036	·19509	31	59	·95689	·20311	1
30	·96025	·19537	30	60	·95677	·20337	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

78 Deg.

102 Deg.

Minutes.	Distance.	Difference in Height.		Minutes	Distance.	Difference in Height.	
0	·95677	·20337	60	30	·95315	·21131	30
1	·95665	·20364	59	31	·95302	·21157	29
2	·95653	·20390	58	32	·95290	·21184	28
3	·95641	·20417	57	33	·95278	·21210	27
4	·95629	·20443	56	34	·95266	·21235	26
5	·95618	·20469	55	35	·95254	·21263	25
6	·95606	·20496	54	36	·95242	·21289	24
7	·95594	·20522	53	37	·95229	·21315	23
8	·95582	·20549	52	38	·95217	·21342	22
9	·95570	·20576	51	39	·95204	·21368	21
10	·95558	·20603	50	40	·95192	·21394	20
11	·95546	·20629	49	41	·95179	·21420	19
12	·95534	·20655	48	42	·95166	·21447	18
13	·95522	·20682	47	43	·95154	·21473	17
14	·95510	·20708	46	44	·95141	·21499	16
15	·95498	·20735	45	45	·95128	·21526	15
16	·95486	·20761	44	46	·95116	·21552	14
17	·95474	·20788	43	47	·95103	·21577	13
18	·95462	·20814	42	48	·95091	·21604	12
19	·95450	·20840	41	49	·95078	·21630	11
20	·95438	·20867	40	50	·95066	·21657	10
21	·95425	·20893	39	51	·95053	·21683	9
22	·95413	·20920	38	52	·95041	·21709	8
23	·95401	·20946	37	53	·95028	·21736	7
24	·95389	·20973	36	54	·95016	·21762	6
25	·95377	·20999	35	55	·95003	·21787	5
26	·95365	·21025	34	56	·94990	·21814	4
27	·95352	·21052	33	57	·94978	·21840	3
28	·95340	·21078	32	58	·94965	·21866	2
29	·95327	·21105	31	59	·94953	·21893	1
30	·95315	·21131	30	60	·94940	·21918	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

77 Deg.

103 Deg.

Minutes.	Distance.	Difference in Height.		Minutes	Distance.	Difference in Height.	
0	·94940	·21918	60	30	·94550	·22700	30
1	·94928	·21944	59	31	·94536	·22726	29
2	·94915	·21971	58	32	·94523	·22751	28
3	·94902	·21997	57	33	·94510	·22777	27
4	·94889	·22023	56	34	·94497	·22804	26
5	·94876	·22049	55	35	·94484	·22829	25
6	·94863	·22075	54	36	·94471	·22855	24
7	·94850	·22101	53	37	·94458	·22880	23
8	·94837	·22128	52	38	·94444	·22907	22
9	·94824	·22153	51	39	·94430	·22933	21
10	·94811	·22179	50	40	·94417	·22958	20
11	·94799	·22206	49	41	·94403	·22985	19
12	·94786	·22232	48	42	·94390	·23010	18
13	·94773	·22257	47	43	·94377	·23036	17
14	·94760	·22284	46	44	·94364	·23061	16
15	·94747	·22310	45	45	·94351	·23088	15
16	·94734	·22336	44	46	·94338	·23113	14
17	·94721	·22362	43	47	·94325	·23139	13
18	·94708	·22388	42	48	·94311	·23164	12
19	·94695	·22414	41	49	·94297	·23191	11
20	·94682	·22440	40	50	·94283	·23217	10
21	·94668	·22466	39	51	·94269	·23242	9
22	·94655	·22492	38	52	·94255	·23268	8
23	·94642	·22518	37	53	·94242	·23294	7
24	·94629	·22544	36	54	·94228	·23310	6
25	·94616	·22570	35	55	·94215	·23345	5
26	·94603	·22595	34	56	·94201	·23371	4
27	·94589	·22622	33	57	·94188	·23397	3
28	·94576	·22648	32	58	·94175	·23423	2
29	·94563	·22673	31	59	·94161	·23448	1
30	·94550	·22700	30	60	·94147	·23473	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

76 Deg.

104 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·94147	·23473	60	30	·93731	·24241	30
1	·94133	·23499	59	31	·93716	·24266	29
2	·94120	·23525	58	32	·93702	·24291	28
3	·94106	·23551	57	33	·93688	·24316	27
4	·94093	·23576	56	34	·93674	·24343	26
5	·94079	·23602	55	35	·93660	·24368	25
6	·94066	·23627	54	36	·93646	·24393	24
7	·94052	·23653	53	37	·93631	·24418	23
8	·94038	·23679	52	38	·93617	·24443	22
9	·94024	·23704	51	39	·93603	·24469	21
10	·94010	·23730	50	40	·93589	·24495	20
11	·93997	·23756	49	41	·93575	·24520	19
12	·93983	·23782	48	42	·93560	·24545	18
13	·93969	·23807	47	43	·93546	·24570	17
14	·93955	·23832	46	44	·93532	·24596	16
15	·93941	·23858	45	45	·93518	·24621	15
16	·93927	·23884	44	46	·93503	·24646	14
17	·93913	·23909	43	47	·93489	·24671	13
18	·93899	·23935	42	48	·93475	·24697	12
19	·93885	·23960	41	49	·93460	·24723	11
20	·93871	·23985	40	50	·93446	·24748	10
21	·93857	·24011	39	51	·93431	·24773	9
22	·93843	·24037	38	52	·93417	·24798	8
23	·93829	·24062	37	53	·93402	·24823	7
24	·93815	·24088	36	54	·93388	·24849	6
25	·93801	·24113	35	55	·93374	·24874	5
26	·93787	·24138	34	56	·93359	·24900	4
27	·93773	·24165	33	57	·93345	·24925	3
28	·93759	·24190	32	58	·93330	·24950	2
29	·93745	·24215	31	59	·93316	·24975	1
30	·93731	·24241	30	60	·93301	·25000	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

75 Deg.

105 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·93301	·25000	60	30	·92858	·25752	30
1	·93286	·25025	59	31	·92843	·25777	29
2	·93271	·25050	58	32	·92828	·25802	28
3	·93256	·25075	57	33	·92813	·25827	27
4	·93242	·25100	56	34	·92798	·25852	26
5	·93228	·25126	55	35	·92783	·25876	25
6	·93214	·25150	54	36	·92768	·25901	24
7	·93200	·25177	53	37	·92753	·25926	23
8	·93185	·25202	52	38	·92738	·25951	22
9	·93170	·25227	51	39	·92723	·25976	21
10	·93155	·25252	50	40	·92708	·26001	20
11	·93140	·25277	49	41	·92692	·26026	19
12	·93125	·25302	48	42	·92677	·26050	18
13	·93110	·25327	47	43	·92662	·26075	17
14	·93096	·25352	46	44	·92647	·26100	16
15	·93081	·25377	45	45	·92632	·26125	15
16	·93067	·25402	44	46	·92616	·26150	14
17	·93052	·25427	43	47	·92601	·26175	13
18	·93037	·25452	42	48	·92586	·26199	12
19	·93022	·25477	41	49	·92571	·26224	11
20	·93007	·25502	40	50	·92556	·26249	10
21	·92992	·25527	39	51	·92540	·26274	9
22	·92977	·25553	38	52	·92525	·26298	8
23	·92962	·25578	37	53	·92509	·26323	7
24	·92947	·25603	36	54	·92494	·26348	6
25	·92933	·25628	35	55	·92479	·26373	5
26	·92918	·25652	34	56	·92463	·26397	4
27	·92903	·25677	33	57	·92448	·26422	3
28	·92888	·25702	32	58	·92432	·26448	2
29	·92873	·25727	31	59	·92417	·26471	1
30	·92858	·25752	30	60	·92402	·26496	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

74 Deg.

106 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·92402	·26496	60	30	·91934	·27232	30
1	·92386	·26521	59	31	·91918	·27256	29
2	·92370	·26546	58	32	·91902	·27280	28
3	·92355	·26570	57	33	·91886	·27305	27
4	·92340	·26595	56	34	·91870	·27329	26
5	·92325	·26620	55	35	·91854	·27354	25
6	·92310	·26643	54	36	·91838	·27378	24
7	·92295	·26668	53	37	·91822	·27403	23
8	·92279	·26693	52	38	·91806	·27427	22
9	·92263	·26717	51	39	·91790	·27451	21
10	·92248	·26742	50	40	·91774	·27475	20
11	·92232	·26766	49	41	·91758	·27500	19
12	·92217	·26791	48	42	·91742	·27524	18
13	·92202	·26816	47	43	·91726	·27548	17
14	·92186	·26840	46	44	·91710	·27573	16
15	·92170	·26865	45	45	·91694	·27597	15
16	·92154	·26890	44	46	·91678	·27621	14
17	·92138	·26914	43	47	·91662	·27645	13
18	·92122	·26939	42	48	·91646	·27669	12
19	·92106	·26963	41	49	·91630	·27694	11
20	·92091	·26988	40	50	·91614	·27718	10
21	·92075	·27012	39	51	·91597	·27743	9
22	·92060	·27037	38	52	·91581	·27767	8
23	·92044	·27061	37	53	·91565	·27790	7
24	·92029	·27085	36	54	·91549	·27814	6
25	·92013	·27110	35	55	·91533	·27839	5
26	·91997	·27134	34	56	·91516	·27863	4
27	·91981	·27159	33	57	·91500	·27888	3
28	·91965	·27183	32	58	·91484	·27912	2
29	·91949	·27208	31	59	·91468	·27935	1
30	·91934	·27232	30	60	·91452	·27959	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

73 Deg.

107 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·91452	·27959	60	30	·90958	·28679	30
1	·91435	·27984	59	31	·90941	·28702	29
2	·91419	·28008	58	32	·90924	·28726	28
3	·91403	·28032	57	33	·90907	·28750	27
4	·91387	·28056	56	34	·90890	·28775	26
5	·91370	·28080	55	35	·90874	·28798	25
6	·91354	·28104	54	36	·90857	·28822	24
7	·91337	·28128	53	37	·90840	·28846	23
8	·91321	·28153	52	38	·90823	·28869	22
9	·91304	·28176	51	39	·90806	·28893	21
10	·91288	·28200	50	40	·90790	·28917	20
11	·91272	·28224	49	41	·90773	·28941	19
12	·91256	·28249	48	42	·90756	·28964	18
13	·91240	·28274	47	43	·90739	·28988	17
14	·91223	·28296	46	44	·90722	·29012	16
15	·91206	·28320	45	45	·90706	·29035	15
16	·91190	·28344	44	46	·90689	·29059	14
17	·91173	·28369	43	47	·90672	·29083	13
18	·91157	·28392	42	48	·90655	·29107	12
19	·91141	·28416	41	49	·90638	·29130	11
20	·91124	·28440	40	50	·90621	·29153	10
21	·91107	·28464	39	51	·90604	·29177	9
22	·91091	·28488	38	52	·90587	·29200	8
23	·91074	·28512	37	53	·90570	·29224	7
24	·91058	·28536	36	54	·90553	·29248	6
25	·91041	·28560	35	55	·90536	·29271	5
26	·91024	·28584	34	56	·90519	·29295	4
27	·91008	·28607	33	57	·90502	·29319	3
28	·90991	·28631	32	58	·90485	·29342	2
29	·90975	·28655	31	59	·90468	·29366	1
30	·90958	·28679	30	60	·90451	·29390	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

72 Deg.

108 Deg. .

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·90451	·29390	60	30	·89932	·30090	30
1	·90434	·29413	59	31	·89914	·30114	29
2	·90417	·29436	58	32	·89897	·30137	28
3	·90400	·29460	57	33	·89879	·30160	27
4	·90382	·29483	56	34	·89862	·30184	26
5	·90365	·29507	55	35	·89844	·30206	25
6	·90348	·29531	54	36	·89826	·30230	24
7	·90331	·29554	53	37	·89809	·30253	23
8	·90314	·29577	52	38	·89791	·30276	22
9	·90297	·29601	51	39	·89774	·30300	21
10	·90279	·29624	50	40	·89756	·30322	20
11	·90261	·29648	49	41	·89738	·30346	19
12	·90244	·29670	48	42	·89721	·30368	18
13	·90227	·29694	47	43	·89703	·30392	17
14	·90210	·29718	46	44	·89686	·30414	16
15	·90193	·29741	45	45	·89668	·30438	15
16	·90175	·29765	44	46	·89650	·30461	14
17	·90158	·29788	43	47	·89633	·30484	13
18	·90140	·29811	42	48	·89615	·30508	12
19	·90123	·29835	41	49	·89597	·30530	11
20	·90106	·29857	40	50	·89579	·30554	10
21	·90088	·29881	39	51	·89562	·30576	9
22	·90071	·29905	38	52	·89544	·30600	8
23	·90053	·29928	37	53	·89526	·30622	7
24	·90036	·29951	36	54	·89508	·30646	6
25	·90019	·29975	35	55	·89490	·30668	5
26	·90001	·29998	34	56	·89473	·30692	4
27	·89984	·30021	33	57	·89455	·30714	3
28	·89967	·30044	32	58	·89437	·30737	2
29	·89949	·30068	31	59	·89419	·30760	1
30	·89932	·30090	30	60	·89401	·30783	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

71 Deg.

109 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·89401	·30783	60	30	·88857	·31466	30
1	·89383	·30806	59	31	·88839	·31488	29
2	·89365	·30829	58	32	·88821	·31512	28
3	·89347	·30851	57	33	·88802	·31534	27
4	·89329	·30875	56	34	·88784	·31556	26
5	·89311	·30897	55	35	·88766	·31579	25
6	·89293	·30921	54	36	·88748	·31601	24
7	·89275	·30943	53	37	·88729	·31624	23
8	·89257	·30966	52	38	·88711	·31646	22
9	·89239	·30989	51	39	·88692	·31669	21
10	·89221	·31012	50	40	·88674	·31692	20
11	·89202	·31034	49	41	·88655	·31714	19
12	·89184	·31058	48	42	·88637	·31738	18
13	·89166	·31080	47	43	·88618	·31759	17
14	·89148	·31103	46	44	·88599	·31781	16
15	·89130	·31126	45	45	·88581	·31804	15
16	·89112	·31149	44	46	·88562	·31826	14
17	·89094	·31171	43	47	·88544	·31848	13
18	·89076	·31194	42	48	·88525	·31871	12
19	·89058	·31217	41	49	·88507	·31893	11
20	·89040	·31239	40	50	·88489	·31916	10
21	·89021	·31262	39	51	·88470	·31938	9
22	·89003	·31285	38	52	·88452	·31961	8
23	·88985	·31308	37	53	·88433	·31984	7
24	·88967	·31330	36	54	·88415	·32006	6
25	·88949	·31357	35	55	·88396	·32028	5
26	·88930	·31376	34	56	·88377	·32050	4
27	·88912	·31398	33	57	·88358	·32072	3
28	·88894	·31421	32	58	·88339	·32094	2
29	·88875	·31443	31	59	·88320	·32117	1
30	·88857	·31466	30	60	·88302	·32139	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

70 Deg.

APPENDIX II.

69

110 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	•88302	•32139	60	30	•87736	•32803	30
1	•88283	•32161	59	31	•87716	•32825	29
2	•88264	•32184	58	32	•87697	•32847	28
3	•88246	•32206	57	33	•87678	•32868	27
4	•88227	•32228	56	34	•87659	•32891	26
5	•88209	•32251	55	35	•87640	•32913	25
6	•88190	•32273	54	36	•87621	•32934	24
7	•88171	•32295	53	37	•87601	•32956	23
8	•88152	•32318	52	38	•87582	•32978	22
9	•88133	•32339	51	39	•87563	•33000	21
10	•88155	•32361	50	40	•87544	•33022	20
11	•88096	•32384	49	41	•87525	•33044	19
12	•88077	•32406	48	42	•87506	•33065	18
13	•88058	•32428	47	43	•87486	•33088	17
14	•88039	•32450	46	44	•87467	•33109	16
15	•88020	•32473	45	45	•87448	•33131	15
16	•88001	•32494	44	46	•87428	•33152	14
17	•87982	•32516	43	47	•87409	•33175	13
18	•87963	•32539	42	48	•87390	•33197	12
19	•87944	•32561	41	49	•87370	•33218	11
20	•87926	•32583	40	50	•87351	•33240	10
21	•87907	•32605	39	51	•87332	•33261	9
22	•87888	•32627	38	52	•87312	•33283	8
23	•87869	•32649	37	53	•87293	•33305	7
24	•87850	•32671	36	54	•87273	•33327	6
25	•87831	•32693	35	55	•87254	•33348	5
26	•87812	•32715	34	56	•87234	•33370	4
27	•87793	•32737	33	57	•87215	•33391	3
28	•87774	•32759	32	58	•87196	•33413	2
29	•87755	•32780	31	59	•87177	•33435	1
30	•87736	•32803	30	60	•87157	•33457	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

69 Deg.

111 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·87157	·33457	60	30	·86568	·34100	30
1	·87138	·33478	59	31	·86548	·34121	29
2	·87118	·33500	58	32	·86528	·34142	28
3	·87099	·33521	57	33	·86508	·34164	27
4	·87079	·33542	56	34	·86488	·34185	26
5	·87060	·33564	55	35	·86468	·34206	25
6	·87040	·33586	54	36	·86448	·34227	24
7	·87021	·33608	53	37	·86428	·34249	23
8	·87001	·33629	52	38	·86408	·34270	22
9	·86982	·33651	51	39	·86388	·34291	21
10	·86962	·33672	50	40	·86369	·34313	20
11	·86942	·33693	49	41	·86349	·34334	19
12	·86923	·33715	48	42	·86329	·34355	18
13	·86903	·33737	47	43	·86309	·34376	17
14	·86884	·33758	46	44	·86289	·34397	16
15	·86864	·33780	45	45	·86269	·34418	15
16	·86844	·33801	44	46	·86248	·34439	14
17	·86824	·33822	43	47	·86228	·34460	13
18	·86804	·33844	42	48	·86208	·34481	12
19	·86784	·33865	41	49	·86188	·34502	11
20	·86765	·33886	40	50	·86168	·34523	10
21	·86745	·33907	39	51	·86148	·34544	9
22	·86726	·33930	38	52	·86128	·34565	8
23	·86706	·33951	37	53	·86108	·34586	7
24	·86687	·33973	36	54	·86088	·34608	6
25	·86667	·33994	35	55	·86068	·34628	5
26	·86647	·34015	34	56	·86047	·34649	4
27	·86627	·34036	33	57	·86027	·34670	3
28	·86607	·34057	32	58	·86007	·34691	2
29	·86587	·34078	31	59	·85987	·34712	1
30	·86568	·34100	30	60	·85967	·34733	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

68 Deg.

APPENDIX II.

71

112 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·85967	·34733	60	30	·85355	·35355	30
1	·85947	·34754	59	31	·85335	·35376	29
2	·85927	·34775	58	32	·85314	·35396	28
3	·85907	·34796	57	33	·85294	·35417	27
4	·85887	·34817	56	34	·85273	·35438	26
5	·85866	·34837	55	35	·85252	·35458	25
6	·85846	·34858	54	36	·85232	·35479	24
7	·85826	·34879	53	37	·85211	·35499	23
8	·85805	·34900	52	38	·85191	·35519	22
9	·85785	·34921	51	39	·85170	·35540	21
10	·85764	·34941	50	40	·85149	·35560	20
11	·85744	·34962	49	41	·85128	·35581	19
12	·85724	·34983	48	42	·85107	·35602	18
13	·85703	·35004	47	43	·85086	·35621	17
14	·85683	·35025	46	44	·85065	·35642	16
15	·85662	·35046	45	45	·85045	·35662	15
16	·85642	·35066	44	46	·85025	·35683	14
17	·85622	·35087	43	47	·85004	·35704	13
18	·85601	·35108	42	48	·84983	·35724	12
19	·85581	·35129	41	49	·84962	·35744	11
20	·85560	·35150	40	50	·84942	·35764	10
21	·85540	·35169	39	51	·84921	·35784	9
22	·85520	·35190	38	52	·84900	·35805	8
23	·85499	·35211	37	53	·84879	·35826	7
24	·85479	·35232	36	54	·84858	·35845	6
25	·85458	·35253	35	55	·84837	·35866	5
26	·85438	·35273	34	56	·84817	·35886	4
27	·85417	·35294	33	57	·84796	·35907	3
28	·85397	·35314	32	58	·84775	·35927	2
29	·85376	·35335	31	59	·84754	·35947	1
30	·85355	·35355	30	60	·84733	·35967	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

67 Deg.

113 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·84733	·35967	60	30	·84100	·36568	30
1	·84702	·35987	59	31	·84078	·36588	29
2	·84681	·36008	58	32	·84056	·36607	28
3	·84660	·36027	57	33	·84035	·36627	27
4	·84639	·36047	56	34	·84014	·36648	26
5	·84628	·36068	55	35	·83993	·36667	25
6	·84607	·36088	54	36	·83972	·36686	24
7	·84586	·36108	53	37	·83951	·36707	23
8	·84565	·36128	52	38	·83930	·36726	22
9	·84544	·36148	51	39	·83909	·36746	21
10	·84523	·36169	50	40	·83887	·36766	20
11	·84502	·36188	49	41	·83865	·36785	19
12	·84481	·36209	48	42	·83843	·36805	18
13	·84460	·36229	47	43	·83821	·36824	17
14	·84439	·36249	46	44	·83800	·36844	16
15	·84418	·36268	45	45	·83779	·36864	15
16	·84397	·36289	44	46	·83758	·36883	14
17	·84376	·36309	43	47	·83736	·36903	13
18	·84355	·36329	42	48	·83715	·36923	12
19	·84334	·36348	41	49	·83693	·36942	11
20	·84312	·36369	40	50	·83672	·36962	10
21	·84291	·36389	39	51	·83650	·36981	9
22	·84270	·36408	38	52	·83631	·37001	8
23	·84249	·36428	37	53	·83609	·37021	7
24	·84228	·36448	36	54	·83587	·37040	6
25	·84206	·36468	35	55	·83564	·37060	5
26	·84185	·36488	34	56	·83542	·37079	4
27	·84164	·36508	33	57	·83520	·37099	3
28	·84143	·36528	32	58	·83499	·37119	2
29	·84122	·36548	31	59	·83478	·37138	1
30	·84100	·36568	30	60	·83457	·37158	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

66 Deg.

APPENDIX II.

73

114 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·83457	·37158	60	30	·82803	·37735	30
1	·83435	·37177	59	31	·82781	·37755	29
2	·83413	·37196	58	32	·82759	·37773	28
3	·83391	·37215	57	33	·82737	·37793	27
4	·83367	·37235	56	34	·82715	·37812	26
5	·83348	·37254	55	35	·82693	·37831	25
6	·83326	·37274	54	36	·82671	·37850	24
7	·83305	·37294	53	37	·82649	·37869	23
8	·83283	·37313	52	38	·82627	·37888	22
9	·83262	·37332	51	39	·82605	·37906	21
10	·83240	·37351	50	40	·82583	·37926	20
11	·83218	·37371	49	41	·82561	·37944	19
12	·83296	·37390	48	42	·82539	·37964	18
13	·83275	·37409	47	43	·82516	·37983	17
14	·83253	·37428	46	44	·82494	·38002	16
15	·83131	·37448	45	45	·82472	·38020	15
16	·83109	·37467	44	46	·82450	·38039	14
17	·83087	·37486	43	47	·82428	·38058	13
18	·83066	·37505	42	48	·82406	·38077	12
19	·83044	·37525	41	49	·82384	·38095	11
20	·83022	·37543	40	50	·82362	·38114	10
21	·83000	·37563	39	51	·82340	·38133	9
22	·82978	·37582	38	52	·82318	·38152	8
23	·82957	·37601	37	53	·82296	·38171	7
24	·82935	·37620	36	54	·82273	·38190	6
25	·82913	·37640	35	55	·82250	·38209	5
26	·82890	·37659	34	56	·82228	·38227	4
27	·82868	·37678	33	57	·82205	·38246	3
28	·82846	·37697	32	58	·82183	·38265	2
29	·82825	·37716	31	59	·82161	·38283	1
30	·82803	·37735	30	60	·82139	·38302	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

65 Deg.

115 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·82139	·38302	60	30	·81466	·38857	30
1	·82117	·38321	59	31	·81443	·38875	29
2	·82095	·38340	58	32	·81420	·38894	28
3	·82073	·38358	57	33	·81397	·38912	27
4	·82050	·38377	56	34	·81375	·38930	26
5	·82028	·38396	55	35	·81353	·38948	25
6	·82006	·38414	54	36	·81330	·38967	24
7	·81984	·38433	53	37	·81307	·38985	23
8	·81961	·38452	52	38	·81284	·39003	22
9	·81938	·38470	51	39	·81261	·39021	21
10	·81916	·38488	50	40	·81239	·39039	20
11	·81893	·38507	49	41	·81216	·39058	19
12	·81870	·38526	48	42	·81194	·39076	18
13	·81847	·38544	47	43	·81172	·39094	17
14	·81824	·38563	46	44	·81149	·39112	16
15	·81802	·38582	45	45	·81126	·39131	15
16	·81780	·38600	44	46	·81103	·39149	14
17	·81758	·38619	43	47	·81080	·39167	13
18	·81736	·38637	42	48	·81057	·39185	12
19	·81714	·38655	41	49	·81034	·39202	11
20	·81692	·38673	40	50	·81012	·39221	10
21	·81670	·38692	39	51	·80989	·39239	9
22	·81648	·38710	38	52	·80966	·39257	8
23	·81625	·38729	37	53	·80943	·39275	7
24	·81602	·38748	36	54	·80920	·39293	6
25	·81579	·38766	35	55	·80898	·39310	5
26	·81557	·38784	34	56	·80875	·39329	4
27	·81535	·38802	33	57	·80852	·39347	3
28	·81512	·38821	32	58	·80829	·39365	2
29	·81489	·38839	31	59	·80806	·39383	1
30	·81466	·38857	30	60	·80783	·39400	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

64 Deg.

APPENDIX II.

75

116 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·80783	·39400	60	30	·80091	·39932	30
1	·80760	·39418	59	31	·80068	·39949	29
2	·80737	·39436	58	32	·80044	·39967	28
3	·80714	·39455	57	33	·80021	·39984	27
4	·80691	·39472	56	34	·79998	·40002	26
5	·80668	·39490	55	35	·79975	·40019	25
6	·80645	·39508	54	36	·79952	·40036	24
7	·80622	·39526	53	37	·79929	·40054	23
8	·80599	·39543	52	38	·79905	·40071	22
9	·80576	·39561	51	39	·79881	·40089	21
10	·80553	·39579	50	40	·79858	·40106	20
11	·80530	·39596	49	41	·79835	·40124	19
12	·80507	·39615	48	42	·79812	·40141	18
13	·80484	·39633	47	43	·79788	·40158	17
14	·80461	·39650	46	44	·79764	·40176	16
15	·80438	·39668	45	45	·79741	·40193	15
16	·80415	·39685	44	46	·79718	·40210	14
17	·80392	·39703	43	47	·79695	·40228	13
18	·80369	·39721	42	48	·79671	·40245	12
19	·80346	·39738	41	49	·79647	·40262	11
20	·80323	·39756	40	50	·79624	·40279	10
21	·80299	·39773	39	51	·79600	·40297	9
22	·80276	·39791	38	52	·79576	·40314	8
23	·80253	·39808	37	53	·79553	·40331	7
24	·80230	·39827	36	54	·79531	·40348	6
25	·80207	·39844	35	55	·79507	·40365	5
26	·80184	·39862	34	56	·79484	·40382	4
27	·80160	·39879	33	57	·79460	·40399	3
28	·80137	·39897	32	58	·79436	·40416	2
29	·80114	·39914	31	59	·79412	·40434	1
30	·80091	·39932	30	60	·79389	·40451	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

63 Deg.

117 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·79389	·40451	60	30	·78679	·40958	30
1	·79366	·40468	59	31	·78655	·40975	29
2	·79342	·40485	58	32	·78631	·40990	28
3	·79319	·40502	57	33	·78607	·41007	27
4	·79295	·40520	56	34	·78583	·41024	26
5	·79272	·40537	55	35	·78565	·41041	25
6	·79248	·40553	54	36	·78536	·41058	24
7	·79224	·40570	53	37	·78512	·41074	23
8	·79201	·40587	52	38	·78488	·41090	22
9	·79177	·40604	51	39	·78464	·41107	21
10	·79153	·40621	50	40	·78440	·41124	20
11	·79130	·40638	49	41	·78416	·41140	19
12	·79106	·40655	48	42	·78392	·41156	18
13	·79083	·40672	47	43	·78368	·41174	17
14	·79059	·40689	46	44	·78354	·41190	16
15	·79035	·40706	45	45	·78320	·41206	15
16	·79011	·40722	44	46	·78296	·41223	14
17	·78988	·40739	43	47	·78272	·41239	13
18	·78964	·40757	42	48	·78248	·41256	12
19	·78940	·40773	41	49	·78224	·41272	11
20	·78917	·40790	40	50	·78200	·41288	10
21	·78893	·40807	39	51	·78176	·41305	9
22	·78869	·40823	38	52	·78152	·41322	8
23	·78845	·40840	37	53	·78128	·41337	7
24	·78822	·40857	36	54	·78104	·41354	6
25	·78798	·40874	35	55	·78080	·41371	5
26	·78774	·40891	34	56	·78056	·41386	4
27	·78750	·40907	33	57	·78032	·41403	3
28	·78726	·40924	32	58	·78008	·41419	2
29	·78703	·40941	31	59	·77984	·41435	1
30	·78679	·40958	30	60	·77960	·41452	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

62 Deg.

118 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·77960	·41452	60	30	·77232	·41934	30
1	·77935	·41468	59	31	·77207	·41949	29
2	·77911	·41485	58	32	·77183	·41965	28
3	·77887	·41501	57	33	·77159	·41981	27
4	·77863	·41517	56	34	·77134	·41997	26
5	·77839	·41533	55	35	·77110	·42013	25
6	·77815	·41549	54	36	·77085	·42028	24
7	·77791	·41566	53	37	·77061	·42044	23
8	·77766	·41582	52	38	·77036	·42059	22
9	·77742	·41598	51	39	·77012	·42075	21
10	·77718	·41615	50	40	·76988	·42091	20
11	·77694	·41630	49	41	·76963	·42107	19
12	·77670	·41646	48	42	·76939	·42122	18
13	·77645	·41663	47	43	·76924	·42139	17
14	·77621	·41678	46	44	·76889	·42154	16
15	·77597	·41694	45	45	·76865	·42170	15
16	·77574	·41711	44	46	·76840	·42185	14
17	·77548	·41726	43	47	·76816	·42201	13
18	·77524	·41743	42	48	·76791	·42216	12
19	·77500	·41758	41	49	·76767	·42232	11
20	·77475	·41774	40	50	·76742	·42247	10
21	·77451	·41791	39	51	·76718	·42263	9
22	·77427	·41806	38	52	·76693	·42279	8
23	·77402	·41823	37	53	·76668	·42295	7
24	·77378	·41838	36	54	·76644	·42309	6
25	·77354	·41854	35	55	·76619	·42325	5
26	·77329	·41870	34	56	·76594	·42341	4
27	·77305	·41886	33	57	·76570	·42356	3
28	·77281	·41902	32	58	·76545	·42371	2
29	·77256	·41918	31	59	·76520	·42387	1
30	·77232	·41934	30	60	·76496	·42402	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

61 Deg.

119 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	•76496	•42402	60	30	•75752	•42858	30
1	•76471	•42418	59	31	•75727	•42874	29
2	•76446	•42433	58	32	•75702	•42888	28
3	•76422	•42449	57	33	•75677	•42903	27
4	•76397	•42464	56	34	•75652	•42918	26
5	•76372	•42479	55	35	•75627	•42933	25
6	•76348	•42495	54	36	•75602	•42948	24
7	•76323	•42510	53	37	•75577	•42962	23
8	•76298	•42525	52	38	•75552	•42978	22
9	•76274	•42546	51	39	•75527	•42992	21
10	•76249	•42556	50	40	•75502	•43007	20
11	•76224	•42571	49	41	•75477	•43023	19
12	•76199	•42586	48	42	•75452	•43037	18
13	•76174	•42601	47	43	•75427	•43052	17
14	•76150	•42617	46	44	•75402	•43066	16
15	•76125	•42632	45	45	•75377	•43082	15
16	•76100	•42647	44	46	•75352	•43096	14
17	•76075	•42662	43	47	•75327	•43111	13
18	•76051	•42677	42	48	•75302	•43126	12
19	•76026	•42693	41	49	•75277	•43141	11
20	•76001	•42708	40	50	•75251	•43155	10
21	•75976	•42723	39	51	•75226	•43170	9
22	•75951	•42738	38	52	•75201	•43184	8
23	•75926	•42753	37	53	•75176	•43199	7
24	•75901	•42768	36	54	•75151	•43214	6
25	•75876	•42783	35	55	•75126	•43228	5
26	•75852	•42798	34	56	•75101	•43243	4
27	•75827	•42813	33	57	•75075	•43257	3
28	•75802	•42829	32	58	•75050	•43273	2
29	•75777	•42813	31	59	•75025	•43287	1
30	•75752	•42858	30	60	•75000	•43302	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

60 Deg.

120 Deg.

Minutes.	Distance.	Difference in Height.		Minutes.	Distance.	Difference in Height.	
0	·75000	·43302	60	30	·74240	·43731	30
1	·74975	·43316	59	31	·74215	·43745	29
2	·74950	·43330	58	32	·74190	·43759	28
3	·74924	·43345	57	33	·74164	·43773	27
4	·74899	·43359	56	34	·74139	·43787	26
5	·74874	·43374	55	35	·74113	·43801	25
6	·74849	·43388	54	36	·74089	·43815	24
7	·74823	·43403	53	37	·74062	·43829	23
8	·74798	·43417	52	38	·74037	·43843	22
9	·74773	·43432	51	39	·74011	·43857	21
10	·74748	·43446	50	40	·73986	·43871	20
11	·74722	·43460	49	41	·73960	·43886	19
12	·74697	·43475	48	42	·73935	·43899	18
13	·74672	·43489	47	43	·73909	·43912	17
14	·74656	·43503	46	44	·73883	·43927	16
15	·74621	·43518	45	45	·73858	·43941	15
16	·74596	·43533	44	46	·73832	·43955	14
17	·74570	·43547	43	47	·73807	·43968	13
18	·74545	·43561	42	48	·73780	·43982	12
19	·74520	·43575	41	49	·73756	·43996	11
20	·74494	·43589	40	50	·73730	·44010	10
21	·74469	·43603	39	51	·73704	·44024	9
22	·74444	·43618	38	52	·73679	·44037	8
23	·74418	·43632	37	53	·73653	·44051	7
24	·74393	·43646	36	54	·73638	·44065	6
25	·74368	·43660	35	55	·73602	·44079	5
26	·74342	·43675	34	56	·73576	·44093	4
27	·74317	·43689	33	57	·73551	·44107	3
28	·74291	·43703	32	58	·73525	·44120	2
29	·74266	·43717	31	59	·73499	·44134	1
30	·74240	·43731	30	60	·73474	·44148	0
	Distance.	Difference in Height.	Minutes.		Distance.	Difference in Height.	Minutes.

59 Deg.

APPENDIX No. III.

TABLE FOR REDUCING DISTANCES AND HEIGHTS (CENTESIMAL DEGREES).

To find the distance or difference in height, multiply the numbers corresponding to the vertical angle in the respective columns by the generating number.

APPENDIX III.

83

100 g.

Angle.	Distance.	Difference in Height.		Angle.	Distance.	Difference in Height.	
100°00	1·00000	·00000	100°00	100°50	·99994	·00785	99°50
01	1·00000	·00016	99°59	51	·99994	·00801	49
02	1·00000	·00031	98	52	·99993	·00817	48
03	1·00000	·00047	97	53	·99993	·00833	47
04	1·00000	·00063	96	54	·99993	·00848	46
05	1·00000	·00079	95	55	·99993	·00864	45
06	1·00000	·00094	94	56	·99992	·00880	44
07	1·00000	·00110	93	57	·99992	·00895	43
08	1·00000	·00126	92	58	·99992	·00911	42
09	1·00000	·00141	91	59	·99991	·00927	41
10	1·00000	·00157	90	60	·99991	·00942	40
11	1·00000	·00173	89	61	·99991	·00958	39
12	1·00000	·00188	88	62	·99991	·00974	38
13	1·00000	·00204	87	63	·99990	·00990	37
14	1·00000	·00220	86	64	·99990	·01005	36
15	1·00000	·00236	85	65	·99990	·01021	35
16	·99999	·00251	84	66	·99989	·01037	34
17	·99999	·00267	83	67	·99989	·01052	33
18	·99999	·00283	82	68	·99989	·01068	32
19	·99999	·00298	81	69	·99988	·01084	31
20	·99999	·00314	80	70	·99988	·01100	30
21	·99999	·00330	79	71	·99988	·01115	29
22	·99999	·00346	78	72	·99987	·01131	28
23	·99999	·00361	77	73	·99987	·01147	27
24	·99999	·00377	76	74	·99987	·01162	26
100°25	·99999	·00393	99°75	100°75	·99986	·01178	99°25
26	·99998	·00408	74	76	·99986	·01194	24
27	·99998	·00424	73	77	·99985	·01209	23
28	·99998	·00440	72	78	·99985	·01225	22
29	·99998	·00456	71	79	·99985	·01241	21
30	·99998	·00471	70	80	·99984	·01257	20
31	·99998	·00487	69	81	·99984	·01272	19
32	·99998	·00503	68	82	·99984	·01288	18
33	·99997	·00518	67	83	·99983	·01304	17
34	·99997	·00534	66	84	·99983	·01319	16
35	·99997	·00550	65	85	·99982	·01335	15
36	·99997	·00565	64	86	·99982	·01351	14
37	·99997	·00581	63	87	·99981	·01366	13
38	·99996	·00597	62	88	·99981	·01382	12
39	·99996	·00613	61	89	·99981	·01398	11
40	·99996	·00628	60	90	·99980	·01414	10
41	·99996	·00644	59	91	·99980	·01429	09
42	·99996	·00660	58	92	·99979	·01445	08
43	·99995	·00675	57	93	·99979	·01461	07
44	·99995	·00691	56	94	·99978	·01476	06
45	·99995	·00707	55	95	·99978	·01492	05
46	·99995	·00723	54	96	·99977	·01508	04
47	·99995	·00738	53	97	·99977	·01523	03
48	·99994	·00754	52	98	·99976	·01539	02
49	·99994	·00770	51	99	·99976	·01555	01
100°50	·99994	·00785	99°50	101°00	·99975	·01571	99°00
	Distance.	Difference in Height.	Angle.		Distance.	Difference in Height.	Angle.

99 g.

APPENDIX III.

101 g.

Angle.	Distance.	Difference in Height.		Angle.	Distance.	Difference in Height.	
101°00	·99975	·01571	99°00	101°50	·99915	·02355	98°50
·01	·99975	·01586	98°99	·51	·99944	·02371	·49
·02	·99971	·01602	·98	·52	·99943	·02387	·48
·03	·99974	·01618	·97	·53	·99912	·02402	·47
·04	·99973	·01633	·96	·54	·99912	·02418	·46
·05	·99973	·01649	·95	·55	·99941	·02434	·45
·06	·99972	·01665	·94	·56	·99910	·02450	·44
·07	·99972	·01680	·93	·57	·99939	·02465	·43
·08	·99971	·01696	·92	·58	·99938	·02481	·42
·09	·99971	·01712	·91	·59	·99938	·02497	·41
·10	·99970	·01728	·90	·60	·99937	·02512	·40
·11	·99970	·01743	·89	·61	·99936	·02528	·39
·12	·99969	·01759	·88	·62	·99935	·02544	·38
·13	·99969	·01775	·87	·63	·99934	·02559	·37
·14	·99968	·01790	·86	·64	·99934	·02575	·36
·15	·99967	·01806	·85	·65	·99933	·02591	·35
·16	·99967	·01822	·84	·66	·99932	·02606	·34
·17	·99966	·01837	·83	·67	·99931	·02622	·33
·18	·99966	·01853	·82	·68	·99930	·02638	·32
·19	·99965	·01869	·81	·69	·99930	·02653	·31
·20	·99965	·01885	·80	·70	·99929	·02669	·30
·21	·99964	·01900	·79	·71	·99928	·02685	·29
·22	·99963	·01916	·78	·72	·99927	·02701	·28
·23	·99963	·01932	·77	·73	·99926	·02716	·27
·24	·99962	·01947	·76	·74	·99925	·02732	·26
101°25	·99962	·01963	98°75	101°75	·99925	·02748	98°25
·26	·99961	·01979	·74	·76	·99924	·02763	·24
·27	·99960	·01994	·73	·77	·99923	·02779	·23
·28	·99960	·02010	·72	·78	·99922	·02795	·22
·29	·99959	·02026	·71	·79	·99921	·02810	·21
·30	·99958	·02042	·70	·80	·99920	·02826	·20
·31	·99958	·02057	·69	·81	·99919	·02842	·19
·32	·99957	·02073	·68	·82	·99918	·02857	·18
·33	·99956	·02089	·67	·83	·99917	·02873	·17
·34	·99956	·02104	·66	·84	·99917	·02889	·16
·35	·99955	·02120	·65	·85	·99916	·02904	·15
·36	·99954	·02136	·64	·86	·99915	·02920	·14
·37	·99954	·02151	·63	·87	·99914	·02936	·13
·38	·99953	·02167	·62	·88	·99913	·02951	·12
·39	·99952	·02183	·61	·89	·99912	·02967	·11
·40	·99952	·02198	·60	·90	·99911	·02983	·10
·41	·99951	·02214	·59	·91	·99910	·02998	·09
·42	·99950	·02230	·58	·92	·99909	·03014	·08
·43	·99950	·02246	·57	·93	·99908	·03030	·07
·44	·99949	·02261	·56	·94	·99907	·03046	·06
·45	·99948	·02277	·55	·95	·99906	·03061	·05
·46	·99948	·02293	·54	·96	·99905	·03077	·04
·47	·99947	·02308	·53	·97	·99904	·03093	·03
·48	·99946	·02324	·52	·98	·99903	·03108	·02
·49	·99945	·02340	·51	·99	·99902	·03124	·01
101°50	·99945	·02355	98°50	102°00	·99901	·03140	98°00
	Distance.	Difference in Height.	Angle.		Distance.	Difference in Height.	Angle.

98 g.

APPENDIX III.

85

102 g.

Angle.	Distance.	Difference in Height.		Angle.	Distance.	Difference in Height.	
102°00	·99901	·03140	98°00	102°50	·99846	·03923	97°50
·01	·99900	·03155	97°99	·51	·99845	·03939	·49
·02	·99899	·03171	·98	·52	·99843	·03954	·48
·03	·99898	·03187	·97	·53	·99842	·03970	·47
·04	·99897	·03202	·96	·54	·99841	·03986	·46
·05	·99896	·03218	·95	·55	·99840	·04001	·45
·06	·99895	·03234	·94	·56	·99838	·04017	·44
·07	·99894	·03249	·93	·57	·99837	·04033	·43
·08	·99893	·03265	·92	·58	·99836	·04048	·42
·09	·99892	·03281	·91	·59	·99835	·04064	·41
·10	·99891	·03296	·90	·60	·99833	·04080	·40
·11	·99890	·03312	·89	·61	·99832	·04095	·39
·12	·99889	·03328	·88	·62	·99831	·04111	·38
·13	·99888	·03343	·87	·63	·99829	·04127	·37
·14	·99887	·03359	·86	·64	·99828	·04142	·36
·15	·99886	·03375	·85	·65	·99827	·04158	·35
·16	·99885	·03390	·84	·66	·99826	·04174	·34
·17	·99884	·03406	·83	·67	·99824	·04189	·33
·18	·99883	·03422	·82	·68	·99823	·04205	·32
·19	·99882	·03437	·81	·69	·99822	·04220	·31
·20	·99881	·03453	·80	·70	·99820	·04236	·30
·21	·99880	·03469	·79	·71	·99819	·04252	·29
·22	·99878	·03484	·78	·72	·99818	·04267	·28
·23	·99877	·03500	·77	·73	·99816	·04283	·27
·24	·99876	·03516	·76	·74	·99815	·04299	·26
102°25	·99875	·03531	97°75	102°75	·99814	·04314	97°25
·26	·99874	·03547	·74	·76	·99812	·04330	·24
·27	·99873	·03563	·73	·77	·99811	·04346	·23
·28	·99872	·03578	·72	·78	·99809	·04361	·22
·29	·99871	·03594	·71	·79	·99808	·04377	·21
·30	·99870	·03610	·70	·80	·99807	·04393	·20
·31	·99868	·03625	·69	·81	·99805	·04408	·19
·32	·99867	·03641	·68	·82	·99804	·04424	·18
·33	·99866	·03657	·67	·83	·99803	·04440	·17
·34	·99865	·03672	·66	·84	·99801	·04455	·16
·35	·99864	·03688	·65	·85	·99800	·04471	·15
·36	·99863	·03704	·64	·86	·99798	·04486	·14
·37	·99862	·03719	·63	·87	·99797	·04502	·13
·38	·99860	·03735	·62	·88	·99796	·04518	·12
·39	·99859	·03751	·61	·89	·99794	·04533	·11
·40	·99858	·03766	·60	·90	·99793	·04549	·10
·41	·99857	·03782	·59	·91	·99791	·04565	·09
·42	·99856	·03798	·58	·92	·99790	·04580	·08
·43	·99854	·03813	·57	·93	·99788	·04596	·07
·44	·99853	·03829	·56	·94	·99787	·04612	·06
·45	·99852	·03845	·55	·95	·99786	·04627	·05
·46	·99851	·03860	·54	·96	·99784	·04643	·04
·47	·99850	·03876	·53	·97	·99783	·04659	·03
·48	·99848	·03892	·52	·98	·99781	·04674	·02
·49	·99847	·03907	·51	·99	·99780	·04690	·01
102°50	·99846	·03923	97°50	103°00	·99778	·04705	97°00
	Distance.	Difference in Height.	Angle.		Distance.	Difference in Height.	Angle.

97 g.

103 g.

Angle.	Distance.	Difference in Height.		Angle.	Distance.	Difference in Height.	
103°00	·99778	·01705	97°00	103°50	·99698	·05487	96°50
01	·99777	·04721	96°99	51	·99696	·05502	49
02	·99775	·04737	98	52	·99695	·05518	48
03	·99774	·04752	97	53	·99693	·05534	47
04	·99772	·04768	96	54	·99691	·05549	46
05	·99771	·04784	95	55	·99689	·05565	45
06	·99769	·04799	94	56	·99688	·05580	44
07	·99768	·04815	93	57	·99686	·05596	43
08	·99766	·04831	92	58	·99684	·05612	42
09	·99765	·04846	91	59	·99682	·05627	41
10	·99763	·04862	90	60	·99681	·05643	40
11	·99762	·04877	89	61	·99679	·05658	39
12	·99760	·04893	88	62	·99677	·05674	38
13	·99759	·04909	87	63	·99675	·05690	37
14	·99757	·04924	86	64	·99674	·05705	36
15	·99755	·04940	85	65	·99672	·05721	35
16	·99754	·04956	84	66	·99670	·05737	34
17	·99752	·04971	83	67	·99668	·05752	33
18	·99751	·04987	82	68	·99666	·05768	32
19	·99749	·05003	81	69	·99664	·05783	31
20	·99748	·05018	80	70	·99663	·05799	30
21	·99746	·05034	79	71	·99661	·05815	29
22	·99744	·05049	78	72	·99659	·05830	28
23	·99743	·05065	77	73	·99657	·05846	27
24	·99741	·05081	76	74	·99655	·05861	26
103°25	·99740	·05096	96°75	103°75	·99653	·05877	96°25
26	·99738	·05112	74	76	·99652	·05893	24
27	·99737	·05128	73	77	·99650	·05908	23
28	·99735	·05143	72	78	·99648	·05924	22
29	·99733	·05159	71	79	·99646	·05939	21
30	·99732	·05174	70	80	·99644	·05955	20
31	·99730	·05190	69	81	·99642	·05971	19
32	·99728	·05206	68	82	·99640	·05986	18
33	·99727	·05221	67	83	·99639	·06002	17
34	·99725	·05237	66	84	·99637	·06017	16
35	·99723	·05253	65	85	·99635	·06033	15
36	·99722	·05268	64	86	·99633	·06048	14
37	·99720	·05284	63	87	·99631	·06064	13
38	·99718	·05299	62	88	·99629	·06080	12
39	·99717	·05315	61	89	·99627	·06095	11
40	·99715	·05331	60	90	·99625	·06111	10
41	·99713	·05346	59	91	·99623	·06126	09
42	·99712	·05362	58	92	·99621	·06142	08
43	·99710	·05377	57	93	·99619	·06158	07
44	·99708	·05393	56	94	·99618	·06173	06
45	·99707	·05409	55	95	·99616	·06189	05
46	·99705	·05424	54	96	·99614	·06204	04
47	·99703	·05440	53	97	·99612	·06220	03
48	·99702	·05456	52	98	·99610	·06236	02
49	·99700	·05471	51	99	·99608	·06251	01
103°50	·99698	·05487	96°50	104°00	·99606	·06267	96°00
	Distance.	Difference in Height.	Angle.		Distance.	Difference in Height.	Angle.

APPENDIX III.

87

104 g.

Angle.	Distance.	Difference in Height.		Angle.	Distance.	Difference in Height.	
104°00	•99606	•06267	96°00	104°50	•99501	•07045	95°50
•01	•99604	•06282	•95°59	•51	•99499	•07061	•49
•02	•99602	•06298	•88	•52	•99497	•07076	•48
•03	•99600	•06313	•97	•53	•99495	•07092	•47
•04	•99598	•06329	•96	•54	•99492	•07107	•46
•05	•99596	•06345	•95	•55	•99490	•07123	•45
•06	•99594	•06360	•94	•56	•99488	•07138	•44
•07	•99592	•06376	•93	•57	•99486	•07154	•43
•08	•99590	•06391	•92	•58	•99483	•07169	•42
•09	•99588	•06407	•91	•59	•99481	•07185	•41
•10	•99586	•06423	•90	•60	•99479	•07201	•40
•11	•99584	•06438	•89	•61	•99477	•07216	•39
•12	•99582	•06454	•88	•62	•99474	•07232	•38
•13	•99580	•06469	•87	•63	•99472	•07247	•37
•14	•99578	•06485	•86	•64	•99470	•07263	•36
•15	•99576	•06500	•85	•65	•99468	•07278	•35
•16	•99574	•06516	•84	•66	•99465	•07294	•34
•17	•99572	•06532	•83	•67	•99463	•07309	•33
•18	•99570	•06547	•82	•68	•99461	•07325	•32
•19	•99568	•06563	•81	•69	•99458	•07340	•31
•20	•99565	•06578	•80	•70	•99456	•07356	•30
•21	•99563	•06594	•79	•71	•99454	•07371	•29
•22	•99561	•06609	•78	•72	•99451	•07387	•28
•23	•99559	•06625	•77	•73	•99449	•07403	•27
•24	•99557	•06641	•76	•74	•99447	•07418	•26
104°25	•99555	•06656	95°75	104°75	•99444	•07434	95°25
•26	•99553	•06672	•74	•76	•99442	•07449	•24
•27	•99551	•06687	•73	•77	•99440	•07465	•23
•28	•99549	•06703	•72	•78	•99437	•07480	•22
•29	•99547	•06718	•71	•79	•99435	•07496	•21
•30	•99544	•06734	•70	•80	•99433	•07511	•20
•31	•99542	•06750	•69	•81	•99430	•07527	•19
•32	•99540	•06765	•68	•82	•99428	•07542	•18
•33	•99538	•06781	•67	•83	•99426	•07558	•17
•34	•99536	•06796	•66	•84	•99423	•07573	•16
•35	•99534	•06812	•65	•85	•99421	•07589	•15
•36	•99532	•06827	•64	•86	•99418	•07604	•14
•37	•99530	•06843	•63	•87	•99416	•07620	•13
•38	•99527	•06858	•62	•88	•99414	•07636	•12
•39	•99525	•06874	•61	•89	•99411	•07651	•11
•40	•99523	•06890	•60	•90	•99409	•07667	•10
•41	•99521	•06905	•59	•91	•99406	•07682	•09
•42	•99519	•06921	•58	•92	•99404	•07698	•08
•43	•99517	•06936	•57	•93	•99402	•07713	•07
•44	•99514	•06952	•56	•94	•99399	•07729	•06
•45	•99512	•06967	•55	•95	•99397	•07744	•05
•46	•99510	•06983	•54	•96	•99394	•07760	•04
•47	•99508	•06998	•53	•97	•99392	•07775	•03
•48	•99506	•07014	•52	•98	•99389	•07791	•02
•49	•99503	•07030	•51	•99	•99387	•07806	•01
104°50	•99501	•07045	95°50	105°00	•99384	•07822	95°00
	Distance.	Difference in Height.	Angle.		Distance.	Difference in Height.	Angle.

95 g.

105 g.

Angle.	Distance.	Difference in Height.		Angle.	Distance.	Difference in Height.	
105°00	•99384	•07822	95°00	105°50	•99256	•08597	94°50
•01	•99382	•07837	94°59	•51	•99253	•08612	•49
•02	•99380	•07853	•98	•52	•99250	•08627	•48
•03	•99377	•07868	•97	•53	•99247	•08643	•47
•04	•99375	•07884	•96	•54	•99245	•08658	•46
•05	•99372	•07899	•95	•55	•99242	•08674	•45
•06	•99370	•07915	•94	•56	•99239	•08689	•44
•07	•99367	•07930	•93	•57	•99237	•08705	•43
•08	•99365	•07946	•92	•58	•99234	•08720	•42
•09	•99362	•07961	•91	•59	•99231	•08736	•41
•10	•99360	•07977	•90	•60	•99228	•08751	•40
•11	•99357	•07992	•89	•61	•99225	•08767	•39
•12	•99355	•08008	•88	•62	•99223	•08782	•38
•13	•99352	•08023	•87	•63	•99220	•08798	•37
•14	•99350	•08039	•86	•64	•99217	•08813	•36
•15	•99347	•08054	•85	•65	•99214	•08829	•35
•16	•99345	•08070	•84	•66	•99212	•08844	•34
•17	•99342	•08085	•83	•67	•99209	•08859	•33
•18	•99339	•08101	•82	•68	•99206	•08875	•32
•19	•99337	•08116	•81	•69	•99203	•08890	•31
•20	•99334	•08132	•80	•70	•99201	•08906	•30
•21	•99332	•08147	•79	•71	•99198	•08921	•29
•22	•99329	•08163	•78	•72	•99195	•08937	•28
•23	•99327	•08178	•77	•73	•99192	•08952	•27
•24	•99324	•08194	•76	•74	•99189	•08968	•26
105°25	•99322	•08209	94°75	105°75	•99187	•08983	94°25
•26	•99319	•08225	•74	•76	•99184	•08999	•24
•27	•99316	•08240	•73	•77	•99181	•09014	•23
•28	•99314	•08256	•72	•78	•99178	•09029	•22
•29	•99311	•08271	•71	•79	•99175	•09045	•21
•30	•99309	•08287	•70	•80	•99172	•09060	•20
•31	•99306	•08302	•69	•81	•99170	•09076	•19
•32	•99303	•08318	•68	•82	•99167	•09091	•18
•33	•99301	•08333	•67	•83	•99164	•09107	•17
•34	•99298	•08349	•66	•84	•99161	•09122	•16
•35	•99295	•08364	•65	•85	•99158	•09138	•15
•36	•99293	•08380	•64	•86	•99155	•09153	•14
•37	•99290	•08395	•63	•87	•99152	•09168	•13
•38	•99288	•08411	•62	•88	•99149	•09184	•12
•39	•99285	•08426	•61	•89	•99147	•09199	•11
•40	•99282	•08442	•60	•90	•99144	•09215	•10
•41	•99280	•08457	•59	•91	•99141	•09230	•09
•42	•99277	•08473	•58	•92	•99138	•09246	•08
•43	•99274	•08488	•57	•93	•99135	•09261	•07
•44	•99272	•08504	•56	•94	•99132	•09277	•06
•45	•99269	•08519	•55	•95	•99129	•09292	•05
•46	•99266	•08535	•54	•96	•99126	•09307	•04
•47	•99264	•08550	•53	•97	•99123	•09323	•03
•48	•99261	•08566	•52	•98	•99120	•09338	•02
•49	•99258	•08581	•51	•99	•99117	•09354	•01
105°50	•99256	•08597	94°50	106°00	•99114	•09369	94°00
	Distance.	Difference in Height.	Angle.		Distance.	Difference in Height.	Angle.

94 g.

106 g.

Angle.	Distance.	Difference in Height.		Angle.	Distance.	Difference in Height.	
106°00	•99114	•09369	94°00	106°50	•98961	•10139	93°50
•01	•99112	•09385	93°99	•51	•98958	•10155	•49
•02	•99109	•09400	•98	•52	•98955	•10170	•48
•03	•99106	•09415	•97	•53	•98952	•10186	•47
•04	•99103	•09431	•96	•54	•98948	•10201	•46
•05	•99100	•09446	•95	•55	•98945	•10216	•45
•06	•99097	•09462	•94	•56	•98942	•10232	•44
•07	•99094	•09477	•93	•57	•98939	•10247	•43
•08	•99091	•09493	•92	•58	•98936	•10262	•42
•09	•99088	•09508	•91	•59	•98932	•10278	•41
•10	•99085	•09523	•90	•60	•98929	•10293	•40
•11	•99082	•09539	•89	•61	•98926	•10309	•39
•12	•99079	•09554	•88	•62	•98923	•10324	•38
•13	•99076	•09570	•87	•63	•98919	•10339	•37
•14	•99073	•09585	•86	•64	•98916	•10355	•36
•15	•99070	•09600	•85	•65	•98913	•10370	•35
•16	•99067	•09616	•84	•66	•98910	•10385	•34
•17	•99064	•09631	•83	•67	•98906	•10401	•33
•18	•99061	•09647	•82	•68	•98903	•10416	•32
•19	•99058	•09662	•81	•69	•98900	•10431	•31
•20	•99055	•09678	•80	•70	•98897	•10447	•30
•21	•99052	•09693	•79	•71	•98893	•10462	•29
•22	•99049	•09708	•78	•72	•98890	•10478	•28
•23	•99046	•09724	•77	•73	•98887	•10493	•27
•24	•99042	•09739	•76	•74	•98883	•10508	•26
93°25	•99039	•09755	93°75	106°75	•98880	•10524	93°25
•26	•99036	•09770	•74	•76	•98877	•10539	•24
•27	•99033	•09785	•73	•77	•98873	•10554	•23
•28	•99030	•09801	•72	•78	•98870	•10570	•22
•29	•99027	•09816	•71	•79	•98867	•10585	•21
•30	•99024	•09832	•70	•80	•98863	•10600	•20
•31	•99021	•09847	•69	•81	•98860	•10616	•19
•32	•99018	•09862	•68	•82	•98857	•10631	•18
•33	•99015	•09878	•67	•83	•98853	•10647	•17
•34	•99012	•09893	•66	•84	•98850	•10662	•16
•35	•99008	•09909	•65	•85	•98847	•10677	•15
•36	•99005	•09924	•64	•86	•98843	•10693	•14
•37	•99002	•09939	•63	•87	•98840	•10708	•13
•38	•98999	•09955	•62	•88	•98837	•10723	•12
•39	•98996	•09970	•61	•89	•98833	•10739	•11
•40	•98993	•09986	•60	•90	•98830	•10754	•10
•41	•98990	•10001	•59	•91	•98827	•10769	•09
•42	•98987	•10016	•58	•92	•98823	•10785	•08
•43	•98983	•10032	•57	•93	•98820	•10800	•07
•44	•98980	•10047	•56	•94	•98816	•10815	•06
•45	•98977	•10063	•55	•95	•98813	•10831	•05
•46	•98974	•10078	•54	•96	•98810	•10846	•04
•47	•98971	•10093	•53	•97	•98806	•10861	•03
•48	•98968	•10109	•52	•98	•98803	•10877	•02
•49	•98964	•10124	•51	•99	•98799	•10892	•01
106°50	•98961	•10139	93°50	107°00	•98796	•10907	93°00
	Distance.	Difference in Height.	Angle.		Distance.	Difference in Height.	Angle.

93 g.

APPENDIX III.

107 g.

Angle.	Distance.	Difference in Height.		Angle.	Distance.	Difference in Height.	
107°00	·98796	·10907	93°00	107°50	·98619	·11672	92°50
·01	·98792	·10923	92°59	·51	·98615	·11688	·49
·02	·98789	·10938	·98	·52	·98611	·11703	·48
·03	·98786	·10953	·97	·53	·98608	·11718	·47
·04	·98782	·10969	·96	·54	·98604	·11733	·46
·05	·98779	·10994	·95	·55	·98600	·11749	·45
·06	·98775	·10999	·94	·56	·98596	·11764	·44
·07	·98772	·11015	·93	·57	·98593	·11779	·43
·08	·98768	·11030	·92	·58	·98589	·11795	·42
·09	·98765	·11045	·91	·59	·98585	·11810	·41
·10	·98761	·11060	·90	·60	·98582	·11825	·40
·11	·98758	·11076	·89	·61	·98578	·11840	·39
·12	·98754	·11091	·88	·62	·98574	·11856	·38
·13	·98751	·11106	·87	·63	·98570	·11871	·37
·14	·98747	·11122	·86	·64	·98567	·11886	·36
·15	·98744	·11137	·85	·65	·98563	·11901	·35
·16	·98740	·11152	·84	·66	·98559	·11917	·34
·17	·98737	·11168	·83	·67	·98556	·11932	·33
·18	·98733	·11183	·82	·68	·98552	·11947	·32
·19	·98730	·11198	·81	·69	·98548	·11962	·31
·20	·98726	·11214	·80	·70	·98544	·11978	·30
·21	·98723	·11229	·79	·71	·98540	·11993	·29
·22	·98719	·11244	·78	·72	·98537	·12008	·28
·23	·98716	·11259	·77	·73	·98533	·12023	·27
·24	·98712	·11275	·76	·74	·98529	·12039	·26
107°25	·98709	·11290	92°75	107°75	·98525	·12054	92°25
·26	·98705	·11305	·74	·76	·98522	·12069	·24
·27	·98702	·11321	·73	·77	·98518	·12084	·23
·28	·98698	·11336	·72	·78	·98514	·12100	·22
·29	·98695	·11351	·71	·79	·98510	·12115	·21
·30	·98691	·11367	·70	·80	·98506	·12130	·20
·31	·98687	·11382	·69	·81	·98503	·12145	·19
·32	·98684	·11397	·68	·82	·98499	·12161	·18
·33	·98680	·11413	·67	·83	·98495	·12176	·17
·34	·98677	·11428	·66	·84	·98491	·12191	·16
·35	·98673	·11443	·65	·85	·98487	·12206	·15
·36	·98669	·11458	·64	·86	·98483	·12221	·14
·37	·98666	·11474	·63	·87	·98480	·12237	·13
·38	·98662	·11489	·62	·88	·98476	·12252	·12
·39	·98659	·11504	·61	·89	·98472	·12267	·11
·40	·98655	·11520	·60	·90	·98468	·12282	·10
·41	·98651	·11535	·59	·91	·98464	·12298	·09
·42	·98648	·11550	·58	·92	·98460	·12313	·08
·43	·98644	·11565	·57	·93	·98456	·12328	·07
·44	·98640	·11581	·56	·94	·98453	·12343	·06
·45	·98637	·11596	·55	·95	·98449	·12358	·05
·46	·98633	·11611	·54	·96	·98445	·12374	·04
·47	·98630	·11627	·53	·97	·98441	·12389	·03
·48	·98626	·11642	·52	·98	·98437	·12404	·02
·49	·98622	·11657	·51	·99	·98433	·12419	·01
107°50	·98619	·11672	92°50	108°00	·98429	·12435	92°00
	Distance.	Difference in Height.	Angle.		Distance.	Difference in Height.	Angle.

92 g.

APPENDIX III.

91

108 g.

Angle.	Distance.	Difference in Height.		Angle.	Distance.	Difference in Height.	
108°00	•98429	•12435	92°00	108°50	•98228	•13194	91°50
•01	•98425	•12450	91°99	•51	•98224	•13209	•49
•02	•98421	•12465	•98	•52	•98220	•13224	•48
•03	•98418	•12480	•97	•53	•98215	•13239	•47
•04	•98414	•12495	•96	•54	•98211	•13254	•46
•05	•98410	•12511	•95	•55	•98207	•13269	•45
•06	•98406	•12526	•94	•56	•98203	•13285	•44
•07	•98402	•12541	•93	•57	•98199	•13300	•43
•08	•98398	•12556	•92	•58	•98195	•13315	•42
•09	•98394	•12571	•91	•59	•98190	•13330	•41
•10	•98390	•12587	•90	•60	•98186	•13345	•40
•11	•98386	•12602	•89	•61	•98182	•13360	•39
•12	•98382	•12617	•88	•62	•98178	•13375	•38
•13	•98378	•12632	•87	•63	•98174	•13391	•37
•14	•98374	•12647	•86	•64	•98169	•13406	•36
•15	•98370	•12663	•85	•65	•98165	•13421	•35
•16	•98366	•12678	•84	•66	•98161	•13436	•34
•17	•98362	•12693	•83	•67	•98157	•13451	•33
•18	•98358	•12708	•82	•68	•98153	•13466	•32
•19	•98354	•12723	•81	•69	•98148	•13481	•31
•20	•98350	•12739	•80	•70	•98144	•13496	•30
•21	•98346	•12754	•79	•71	•98140	•13512	•29
•22	•98342	•12769	•78	•72	•98136	•13527	•28
•23	•98338	•12784	•77	•73	•98131	•13542	•27
•24	•98334	•12799	•76	•74	•98127	•13557	•26
108°25	•98330	•12815	91°75	108°75	•98123	•13572	91°25
•26	•98326	•12830	•74	•76	•98119	•13587	•24
•27	•98322	•12845	•73	•77	•98114	•13602	•23
•28	•98318	•12860	•72	•78	•98110	•13617	•22
•29	•98314	•12875	•71	•79	•98106	•13633	•21
•30	•98310	•12890	•70	•80	•98101	•13648	•20
•31	•98306	•12906	•69	•81	•98097	•13663	•19
•32	•98302	•12921	•68	•82	•98093	•13678	•18
•33	•98298	•12936	•67	•83	•98089	•13693	•17
•34	•98294	•12951	•66	•84	•98084	•13708	•16
•35	•98290	•12966	•65	•85	•98080	•13723	•15
•36	•98285	•12981	•64	•86	•98076	•13738	•14
•37	•98281	•12997	•63	•87	•98071	•13753	•13
•38	•98277	•13012	•62	•88	•98067	•13768	•12
•39	•98273	•13027	•61	•89	•98063	•13784	•11
•40	•98269	•13042	•60	•90	•98058	•13799	•10
•41	•98265	•13057	•59	•91	•98054	•13814	•09
•42	•98261	•13072	•58	•92	•98050	•13829	•08
•43	•98257	•13088	•57	•93	•98045	•13844	•07
•44	•98253	•13103	•56	•94	•98041	•13859	•06
•45	•98249	•13118	•55	•95	•98037	•13874	•05
•46	•98244	•13133	•54	•96	•98032	•13889	•04
•47	•98240	•13148	•53	•97	•98028	•13904	•03
•48	•98236	•13163	•52	•98	•98024	•13919	•02
•49	•98232	•13179	•51	•99	•98019	•13935	•01
108°50	•98228	•13194	91°50	109°00	•98015	•13950	91°00
	Distance.	Difference in Height.	Angle.		Distance.	Difference in Height.	Angle.

91 g.

APPENDIX III.

109 g.

Angle.	Distance.	Difference in Height.		Angle.	Distance.	Difference in Height.	
109°00	·98015	·13950	91°00	109°50	·97790	·14702	90°50
01	·98010	·13965	90°99	51	·97786	·14717	49
02	·98006	·13980	98	52	·97780	·14732	48
03	·98002	·13995	97	53	·97776	·14747	47
04	·97997	·14010	96	54	·97771	·14762	46
05	·97993	·14025	95	55	·97767	·14777	45
06	·97988	·14040	94	56	·97762	·14792	44
07	·97984	·14055	93	57	·97757	·14807	43
08	·97980	·14070	92	58	·97753	·14822	42
09	·97975	·14085	91	59	·97748	·14837	41
10	·97971	·14100	90	60	·97743	·14852	40
11	·97966	·14115	89	61	·97739	·14867	39
12	·97962	·14130	88	62	·97734	·14882	38
13	·97957	·14146	87	63	·97729	·14897	37
14	·97953	·14161	86	64	·97725	·14912	36
15	·97948	·14176	85	65	·97720	·14927	35
16	·97944	·14191	84	66	·97715	·14942	34
17	·97940	·14206	83	67	·97710	·14957	33
18	·97935	·14221	82	68	·97706	·14972	32
19	·97931	·14236	81	69	·97701	·14987	31
20	·97926	·14251	80	70	·97696	·15002	30
21	·97922	·14266	79	71	·97692	·15017	29
22	·97917	·14281	78	72	·97687	·15032	28
23	·97913	·14296	77	73	·97682	·15047	27
24	·97908	·14311	76	74	·97677	·15062	26
109°25	·97904	·14326	90°75	109°75	·97673	·15077	90°25
26	·97899	·14341	74	76	·97668	·15092	24
27	·97895	·14356	73	77	·97663	·15107	23
28	·97890	·14371	72	78	·97659	·15122	22
29	·97886	·14387	71	79	·97654	·15137	21
30	·97881	·14402	70	80	·97649	·15152	20
31	·97877	·14417	69	81	·97644	·15167	19
32	·97872	·14432	68	82	·97640	·15182	18
33	·97868	·14447	67	83	·97635	·15197	17
34	·97863	·14462	66	84	·97630	·15212	16
35	·97858	·14477	65	85	·97625	·15227	15
36	·97854	·14492	64	86	·97620	·15242	14
37	·97849	·14507	63	87	·97616	·15257	13
38	·97845	·14522	62	88	·97611	·15272	12
39	·97840	·14537	61	89	·97606	·15286	11
40	·97836	·14552	60	90	·97601	·15301	10
41	·97831	·14567	59	91	·97596	·15316	09
42	·97826	·14582	58	92	·97592	·15331	08
43	·97822	·14597	57	93	·97587	·15346	07
44	·97817	·14612	56	94	·97582	·15361	06
45	·97813	·14627	55	95	·97577	·15376	05
46	·97808	·14642	54	96	·97572	·15391	04
47	·97804	·14657	53	97	·97567	·15406	03
48	·97799	·14672	52	98	·97563	·15421	02
49	·97794	·14687	51	99	·97558	·15436	01
109°50	·97790	·14702	90°50	110°00	·97553	·15451	90°00
	Distance.	Difference in Height.	Angle.		Distance.	Difference in Height.	Angle.

80 g.

110 g.

Angle.	Distance.	Difference in Height.		Angle.	Distance.	Difference in Height.	
110°00	·97553	·15451	89°00	110°50	·97304	·16196	89°50
01	·97548	·15466	89°09	51	·97299	·16211	49
02	·97543	·15481	98	52	·97294	·16226	48
03	·97538	·15496	97	53	·97289	·16241	47
04	·97533	·15511	96	54	·97284	·16255	46
05	·97529	·15526	95	55	·97279	·16270	45
06	·97524	·15540	94	56	·97274	·16285	44
07	·97519	·15555	93	57	·97269	·16300	43
08	·97514	·15570	92	58	·97264	·16315	42
09	·97509	·15585	91	59	·97258	·16330	41
10	·97504	·15600	90	60	·97253	·16344	40
11	·97499	·15615	89	61	·97248	·16359	39
12	·97494	·15630	88	62	·97243	·16374	38
13	·97489	·15645	87	63	·97238	·16389	37
14	·97484	·15660	86	64	·97233	·16404	36
15	·97480	·15675	85	65	·97228	·16419	35
16	·97475	·15690	84	66	·97222	·16433	34
17	·97470	·15705	83	67	·97217	·16448	33
18	·97465	·15720	82	68	·97212	·16463	32
19	·97460	·15734	81	69	·97207	·16478	31
20	·97455	·15749	80	70	·97202	·16493	30
21	·97450	·15764	79	71	·97196	·16508	29
22	·97445	·15779	78	72	·97191	·16522	28
23	·97440	·15794	77	73	·97186	·16537	27
24	·97435	·15809	76	74	·97181	·16552	26
110°25	·97430	·15824	89°75	110°75	·97176	·16567	89°25
26	·97425	·15839	74	76	·97171	·16582	24
27	·97420	·15854	73	77	·97165	·16597	23
28	·97415	·15869	72	78	·97160	·16611	22
29	·97410	·15883	71	79	·97155	·16626	21
30	·97405	·15898	70	80	·97150	·16641	20
31	·97400	·15913	69	81	·97144	·16656	19
32	·97395	·15928	68	82	·97139	·16671	18
33	·97390	·15943	67	83	·97134	·16685	17
34	·97385	·15958	66	84	·97129	·16700	16
35	·97380	·15973	65	85	·97123	·16715	15
36	·97375	·15988	64	86	·97118	·16730	14
37	·97370	·16003	63	87	·97113	·16745	13
38	·97365	·16017	62	88	·97108	·16759	12
39	·97360	·16032	61	89	·97102	·16774	11
40	·97355	·16047	60	90	·97097	·16789	10
41	·97350	·16062	59	91	·97092	·16804	09
42	·97345	·16077	58	92	·97086	·16819	08
43	·97340	·16092	57	93	·97081	·16833	07
44	·97335	·16107	56	94	·97076	·16848	06
45	·97330	·16122	55	95	·97071	·16863	05
46	·97325	·16136	54	96	·97065	·16878	04
47	·97320	·16151	53	97	·97060	·16893	03
48	·97315	·16166	52	98	·97055	·16907	02
49	·97309	·16181	51	99	·97049	·16922	01
110°50	·97304	·16196	89°50	111°00	·97044	·16937	89°00
	Distance.	Difference in Height.	Angle.		Distance.	Difference in Height.	Angle.

111 g.

Angle.	Distance.	Difference in Height.		Angle.	Distance.	Difference in Height.	
111°00	•97014	•16937	89°00	111°50	•96772	•17674	88°50
01	•97039	•16952	88°99	51	•96767	•17688	49
02	•97033	•16966	98	52	•96761	•17703	48
03	•97028	•16981	97	53	•96756	•17718	47
04	•97023	•16996	96	54	•96750	•17733	46
05	•97017	•17011	95	55	•96744	•17747	45
06	•97012	•17026	94	56	•96739	•17762	44
07	•97007	•17040	93	57	•96733	•17777	43
08	•97001	•17055	92	58	•96728	•17791	42
09	•96996	•17070	91	59	•96722	•17806	41
10	•96991	•17085	90	60	•96716	•17821	40
11	•96985	•17099	89	61	•96711	•17835	39
12	•96980	•17114	88	62	•96705	•17850	38
13	•96975	•17129	87	63	•96700	•17865	37
14	•96969	•17144	86	64	•96694	•17879	36
15	•96964	•17158	85	65	•96689	•17894	35
16	•96958	•17173	84	66	•96683	•17909	34
17	•96953	•17188	83	67	•96677	•17923	33
18	•96948	•17203	82	68	•96672	•17938	32
19	•96942	•17217	81	69	•96666	•17953	31
20	•96937	•17232	80	70	•96660	•17967	30
21	•96931	•17247	79	71	•96655	•17982	29
22	•96926	•17262	78	72	•96649	•17997	28
23	•96920	•17276	77	73	•96643	•18011	27
24	•96915	•17291	76	74	•96638	•18026	26
111°25	•96910	•17306	88°75	111°75	•96632	•18041	88°25
26	•96904	•17321	74	76	•96626	•18055	24
27	•96899	•17335	73	77	•96621	•18070	23
28	•96893	•17350	72	78	•96615	•18085	22
29	•96888	•17365	71	79	•96609	•18099	21
30	•96882	•17380	70	80	•96604	•18114	20
31	•96877	•17394	69	81	•96598	•18128	19
32	•96871	•17409	68	82	•96592	•18143	18
33	•96866	•17424	67	83	•96587	•18158	17
34	•96860	•17438	66	84	•96581	•18172	16
35	•96855	•17453	65	85	•96575	•18187	15
36	•96850	•17468	64	86	•96569	•18202	14
37	•96844	•17483	63	87	•96564	•18216	13
38	•96839	•17497	62	88	•96558	•18231	12
39	•96833	•17512	61	89	•96553	•18246	11
40	•96828	•17527	60	90	•96546	•18260	10
41	•96822	•17541	59	91	•96541	•18275	09
42	•96817	•17556	58	92	•96535	•18289	08
43	•96811	•17571	57	93	•96529	•18304	07
44	•96805	•17586	56	94	•96523	•18319	06
45	•96800	•17600	55	95	•96518	•18333	05
46	•96794	•17615	54	96	•96512	•18348	04
47	•96789	•17630	53	97	•96506	•18362	03
48	•96783	•17644	52	98	•96500	•18377	02
49	•96778	•17659	51	99	•96495	•18392	01
111°50	•96772	•17674	88°50	112°00	•96489	•18406	88°00
	Distance.	Difference in Height.	Angle.		Distance.	Difference in Height.	Angle.

APPENDIX III.

95

112 g.

Angle.	Distance.	Difference in Height.		Angle.	Distance.	Difference in Height.	
112°00	•96489	•18106	88°00	112°50	•96194	•19134	87°50
•01	•96483	•18121	87°99	•51	•96188	•19144	•49
•02	•96477	•18135	•98	•52	•96182	•19163	•48
•03	•96471	•18150	•97	•53	•96176	•19178	•47
•04	•96466	•18165	•96	•54	•96170	•19192	•46
•05	•96460	•18179	•95	•55	•96164	•19207	•45
•06	•96151	•18194	•94	•56	•96158	•19221	•44
•07	•96148	•18508	•93	•57	•96152	•19236	•43
•08	•96142	•18523	•92	•58	•96146	•19250	•42
•09	•96437	•18538	•91	•59	•96140	•19265	•41
•10	•96431	•18552	•90	•60	•96134	•19279	•40
•11	•96125	•18567	•89	•61	•96128	•19294	•39
•12	•96119	•18581	•88	•62	•96122	•19308	•38
•13	•96113	•18596	•87	•63	•96116	•19323	•37
•14	•96407	•18611	•86	•64	•96109	•19337	•36
•15	•96392	•18625	•85	•65	•96103	•19352	•35
•16	•96396	•18610	•84	•66	•96097	•19366	•34
•17	•96390	•18654	•83	•67	•96091	•19381	•33
•18	•96384	•18669	•82	•68	•96085	•19395	•32
•19	•96378	•18683	•81	•69	•96079	•19410	•31
•20	•96372	•18698	•80	•70	•96073	•19424	•30
•21	•96366	•18713	•79	•71	•96067	•19439	•29
•22	•96360	•18727	•78	•72	•96061	•19453	•28
•23	•96355	•18742	•77	•73	•96055	•19467	•27
•24	•96349	•18756	•76	•74	•96048	•19482	•26
112°25	•96343	•18771	87°75	112°75	•96042	•19496	87°25
•26	•96337	•18785	•74	•76	•96036	•19511	•24
•27	•96331	•18800	•73	•77	•96030	•19525	•23
•28	•96325	•18814	•72	•78	•96024	•19540	•22
•29	•96319	•18829	•71	•79	•96018	•19554	•21
•30	•96313	•18844	•70	•80	•96012	•19569	•20
•31	•96307	•18858	•69	•81	•96005	•19583	•19
•32	•96301	•18873	•68	•82	•95999	•19598	•18
•33	•96295	•18887	•67	•83	•95993	•19612	•17
•34	•96290	•18902	•66	•84	•95987	•19627	•16
•35	•96284	•18916	•65	•85	•95981	•19641	•15
•36	•96278	•18931	•64	•86	•95975	•19655	•14
•37	•96272	•18945	•63	•87	•95969	•19670	•13
•38	•96266	•18960	•62	•88	•95962	•19684	•12
•39	•96260	•18975	•61	•89	•95956	•19699	•11
•40	•96254	•18989	•60	•90	•95950	•19713	•10
•41	•96248	•19004	•59	•91	•95944	•19728	•09
•42	•96242	•19018	•58	•92	•95938	•19742	•08
•43	•96236	•19033	•57	•93	•95931	•19756	•07
•44	•96230	•19047	•56	•94	•95925	•19771	•06
•45	•96224	•19062	•55	•95	•95919	•19785	•05
•46	•96218	•19076	•54	•96	•95913	•19800	•04
•47	•96212	•19091	•53	•97	•95906	•19814	•03
•48	•96206	•19105	•52	•98	•95900	•19829	•02
•49	•96200	•19120	•51	•99	•95894	•19843	•01
112°50	•96194	•19134	87°50	113°00	•95888	•19857	87°00
	Distance.	Difference in Height.	Angle.		Distance.	Difference in Height.	Angle.

87 g.

113 g.

Angle.	Distance.	Difference in Height.	.	Angle.	Distance.	Difference in Height.	.
113°00	·95888	·19857	87°00	113°50	·95570	·20576	86°50
01	·95882	·19872	86°09	51	·95561	·20590	49
02	·95875	·19886	08	52	·95557	·20604	48
03	·95869	·19901	07	53	·95551	·20619	47
04	·95863	·19915	06	54	·95544	·20633	46
05	·95857	·19930	05	55	·95538	·20647	45
06	·95850	·19944	04	56	·95531	·20662	44
07	·95844	·19958	03	57	·95525	·20676	43
08	·95838	·19973	02	58	·95518	·20690	42
09	·95831	·19987	01	59	·95512	·20705	41
10	·95825	·20002	00	60	·95505	·20719	40
11	·95819	·20016	89	61	·95499	·20733	39
12	·95813	·20030	88	62	·95492	·20747	38
13	·95806	·20045	87	63	·95486	·20762	37
14	·95800	·20059	86	64	·95479	·20776	36
15	·95794	·20073	85	65	·95473	·20790	35
16	·95787	·20088	84	66	·95466	·20805	34
17	·95781	·20102	83	67	·95460	·20819	33
18	·95775	·20117	82	68	·95453	·20833	32
19	·95768	·20131	81	69	·95447	·20847	31
20	·95762	·20145	80	70	·95440	·20862	30
21	·95756	·20160	79	71	·95433	·20876	29
22	·95749	·20174	78	72	·95427	·20890	28
23	·95743	·20188	77	73	·95420	·20904	27
24	·95737	·20203	76	74	·95414	·20919	26
113°25	·95730	·20217	86°75	113°75	·95407	·20933	86°25
26	·95724	·20232	74	76	·95401	·20947	24
27	·95718	·20246	73	77	·95394	·20962	23
28	·95711	·20260	72	78	·95387	·20976	22
29	·95705	·20275	71	79	·95381	·20990	21
30	·95699	·20289	70	80	·95374	·21004	20
31	·95692	·20303	69	81	·95368	·21019	19
32	·95686	·20318	68	82	·95361	·21033	18
33	·95680	·20332	67	83	·95354	·21047	17
34	·95673	·20346	66	84	·95348	·21061	16
35	·95667	·20361	65	85	·95341	·21076	15
36	·95660	·20375	64	86	·95335	·21090	14
37	·95654	·20390	63	87	·95328	·21104	13
38	·95647	·20404	62	88	·95321	·21118	12
39	·95641	·20418	61	89	·95315	·21133	11
40	·95635	·20433	60	90	·95308	·21147	10
41	·95628	·20447	59	91	·95301	·21161	09
42	·95622	·20461	58	92	·95295	·21175	08
43	·95615	·20476	57	93	·95288	·21190	07
44	·95609	·20490	56	94	·95281	·21204	06
45	·95603	·20504	55	95	·95275	·21218	05
46	·95596	·20518	54	96	·95268	·21232	04
47	·95590	·20533	53	97	·95261	·21246	03
48	·95583	·20547	52	98	·95255	·21261	02
49	·95577	·20561	51	99	·95248	·21275	01
113°50	·95570	·20576	86°50	114°00	·95241	·21289	86°00
	Distance.	Difference in Height.	Angle.		Distance.	Difference in Height.	Angle.

APPENDIX III.

97

114 g.

Angle.	Distance.	Difference in Height.		Angle.	Distance.	Difference in Height.	
114°00	·95241	·21289	86°00	114°50	·94901	·21997	85°50
·01	·95235	·21303	85°59	·51	·94895	·22011	·49
·02	·95228	·21317	·98	·52	·94888	·22025	·48
·03	·95221	·21332	·97	·53	·94881	·22039	·47
·04	·95215	·21346	·96	·54	·94874	·22053	·46
·05	·95208	·21360	·95	·55	·94867	·22068	·45
·06	·95201	·21374	·94	·56	·94860	·22082	·44
·07	·95195	·21388	·93	·57	·94853	·22096	·43
·08	·95188	·21403	·92	·58	·94846	·22110	·42
·09	·95181	·21417	·91	·59	·94839	·22124	·41
·10	·95174	·21431	·90	·60	·94832	·22138	·40
·11	·95168	·21445	·89	·61	·94825	·22152	·39
·12	·95161	·21459	·88	·62	·94818	·22166	·38
·13	·95154	·21474	·87	·63	·94811	·22180	·37
·14	·95147	·21488	·86	·64	·94804	·22194	·36
·15	·95141	·21502	·85	·65	·94797	·22208	·35
·16	·95134	·21516	·84	·66	·94790	·22222	·34
·17	·95127	·21530	·83	·67	·94783	·22236	·33
·18	·95120	·21544	·82	·68	·94776	·22251	·32
·19	·95114	·21559	·81	·69	·94769	·22265	·31
·20	·95107	·21573	·80	·70	·94762	·22279	·30
·21	·95100	·21587	·79	·71	·94755	·22293	·29
·22	·95093	·21601	·78	·72	·94748	·22307	·28
·23	·95086	·21615	·77	·73	·94741	·22321	·27
·24	·95080	·21629	·76	·74	·94734	·22335	·26
114°25	·95073	·21644	85°75	114°75	·94727	·22349	85°25
·26	·95066	·21658	·74	·76	·94720	·22363	·24
·27	·95059	·21672	·73	·77	·94713	·22377	·23
·28	·95052	·21686	·72	·78	·94706	·22391	·22
·29	·95046	·21700	·71	·79	·94699	·22405	·21
·30	·95039	·21714	·70	·80	·94692	·22419	·20
·31	·95032	·21729	·69	·81	·94685	·22433	·19
·32	·95025	·21743	·68	·82	·94678	·22447	·18
·33	·95018	·21757	·67	·83	·94671	·22461	·17
·34	·95011	·21771	·66	·84	·94664	·22475	·16
·35	·95005	·21785	·65	·85	·94657	·22489	·15
·36	·94998	·21799	·64	·86	·94650	·22503	·14
·37	·94991	·21813	·63	·87	·94643	·22517	·13
·38	·94984	·21828	·62	·88	·94636	·22531	·12
·39	·94977	·21842	·61	·89	·94629	·22545	·11
·40	·94970	·21856	·60	·90	·94621	·22559	·10
·41	·94963	·21870	·59	·91	·94614	·22573	·09
·42	·94957	·21884	·58	·92	·94607	·22587	·08
·43	·94950	·21898	·57	·93	·94600	·22601	·07
·44	·94943	·21912	·56	·94	·94593	·22615	·06
·45	·94936	·21926	·55	·95	·94586	·22630	·05
·46	·94929	·21941	·54	·96	·94579	·22644	·04
·47	·94922	·21955	·53	·97	·94572	·22658	·03
·48	·94915	·21969	·52	·98	·94565	·22672	·02
·49	·94908	·21983	·51	·99	·94557	·22686	·01
114°50	·94901	·21997	85°50	115°00	·94550	·22700	85°00
	Distance.	Difference in Height.	Angle.		Distance.	Difference in Height.	Angle.

85 g.

115 g.

Angle.	Distance.	Difference in Height.		Angle.	Distance.	Difference in Height.	
115°00	•94550	•22700	85°00	115°50	•94188	•23397	84°50
•01	•94543	•22714	84°09	•51	•94181	•23410	•49
•02	•94536	•22728	•98	•52	•94174	•23424	•48
•03	•94529	•22742	•97	•53	•94166	•23438	•47
•04	•94522	•22756	•96	•54	•94159	•23452	•46
•05	•94515	•22770	•95	•55	•94152	•23466	•45
•06	•94508	•22783	•94	•56	•94144	•23480	•44
•07	•94500	•22797	•93	•57	•94137	•23494	•43
•08	•94493	•22811	•92	•58	•94129	•23508	•42
•09	•94486	•22825	•91	•59	•94122	•23521	•41
•10	•94479	•22839	•90	•60	•94115	•23535	•40
•11	•94472	•22853	•89	•61	•94107	•23549	•39
•12	•94464	•22867	•88	•62	•94100	•23563	•38
•13	•94457	•22881	•87	•63	•94092	•23577	•37
•14	•94450	•22895	•86	•64	•94085	•23591	•36
•15	•94443	•22909	•85	•65	•94078	•23605	•35
•16	•94436	•22923	•84	•66	•94070	•23618	•34
•17	•94429	•22937	•83	•67	•94063	•23632	•33
•18	•94421	•22951	•82	•68	•94055	•23646	•32
•19	•94414	•22965	•81	•69	•94048	•23660	•31
•20	•94407	•22979	•80	•70	•94040	•23674	•30
•21	•94400	•22993	•79	•71	•94033	•23688	•29
•22	•94392	•23007	•78	•72	•94026	•23701	•28
•23	•94385	•23021	•77	•73	•94018	•23715	•27
•24	•94378	•23035	•76	•74	•94011	•23729	•26
115°25	•94371	•23049	84°75	115°75	•94003	•23743	84°25
•26	•94363	•23063	•74	•76	•93996	•23757	•24
•27	•94356	•23077	•73	•77	•93988	•23770	•23
•28	•94349	•23091	•72	•78	•93981	•23784	•22
•29	•94342	•23105	•71	•79	•93973	•23798	•21
•30	•94334	•23118	•70	•80	•93966	•23812	•20
•31	•94327	•23132	•69	•81	•93958	•23826	•19
•32	•94320	•23146	•68	•82	•93951	•23840	•18
•33	•94313	•23160	•67	•83	•93943	•23853	•17
•34	•94305	•23174	•66	•84	•93936	•23867	•16
•35	•94298	•23188	•65	•85	•93928	•23881	•15
•36	•94291	•23202	•64	•86	•93921	•23895	•14
•37	•94284	•23216	•63	•87	•93913	•23909	•13
•38	•94276	•23230	•62	•88	•93906	•23922	•12
•39	•94269	•23244	•61	•89	•93898	•23936	•11
•40	•94262	•23258	•60	•90	•93891	•23950	•10
•41	•94254	•23272	•59	•91	•93883	•23964	•09
•42	•94247	•23285	•58	•92	•93876	•23978	•08
•43	•94240	•23299	•57	•93	•93868	•23991	•07
•44	•94232	•23313	•56	•94	•93861	•24005	•06
•45	•94225	•23327	•55	•95	•93853	•24019	•05
•46	•94218	•23341	•54	•96	•93846	•24033	•04
•47	•94210	•23355	•53	•97	•93838	•24046	•03
•48	•94203	•23369	•52	•98	•93830	•24060	•02
•49	•94196	•23383	•51	•99	•93823	•24074	•01
115°50	•94188	•23397	84°50	116°00	•93815	•24088	84°00
	Distance.	Difference in Height.	Angle.		Distance.	Difference in Height.	Angle.

APPENDIX III.

99

116 g.

Angle.	Distance.	Difference in Height.		Angle.	Distance.	Difference in Height.	
116°00	•93815	•24088	84°00	116°50	•93432	•24773	83°50
•01	•93808	•24102	83°99	•51	•93124	•24787	•49
•02	•93800	•24115	•98	•52	•93416	•24800	•48
•03	•93793	•24129	•97	•53	•93408	•24814	•47
•04	•93785	•24143	•96	•54	•93400	•24828	•46
•05	•93777	•24157	•95	•55	•93393	•24841	•45
•06	•93770	•24170	•94	•56	•93385	•24855	•44
•07	•93762	•24184	•93	•57	•93377	•24868	•43
•08	•93755	•24198	•92	•58	•93369	•24882	•42
•09	•93747	•24211	•91	•59	•93361	•24896	•41
•10	•93739	•24225	•90	•60	•93354	•24909	•40
•11	•93732	•24239	•89	•61	•93346	•24923	•39
•12	•93724	•24253	•88	•62	•93338	•24937	•38
•13	•93717	•24266	•87	•63	•93330	•24950	•37
•14	•93709	•24280	•86	•64	•93322	•24964	•36
•15	•93701	•24294	•85	•65	•93314	•24977	•35
•16	•93694	•24308	•84	•66	•93307	•24991	•34
•17	•93686	•24321	•83	•67	•93299	•25005	•33
•18	•93678	•24335	•82	•68	•93291	•25018	•32
•19	•93671	•24349	•81	•69	•93283	•25032	•31
•20	•93663	•24363	•80	•70	•93275	•25045	•30
•21	•93655	•24376	•79	•71	•93267	•25059	•29
•22	•93648	•24390	•78	•72	•93259	•25073	•28
•23	•93640	•24404	•77	•73	•93251	•25086	•27
•24	•93633	•24417	•76	•74	•93244	•25100	•26
116°25	•93625	•24431	83°75	116°75	•93236	•25113	83°25
•26	•93617	•24445	•74	•76	•93228	•25127	•24
•27	•93610	•24459	•73	•77	•93220	•25140	•23
•28	•93602	•24472	•72	•78	•93212	•25154	•22
•29	•93594	•24486	•71	•79	•93204	•25168	•21
•30	•93586	•24500	•70	•80	•93196	•25181	•20
•31	•93579	•24513	•69	•81	•93188	•25195	•19
•32	•93571	•24527	•68	•82	•93180	•25208	•18
•33	•93563	•24541	•67	•83	•93172	•25222	•17
•34	•93556	•24554	•66	•84	•93164	•25235	•16
•35	•93548	•24568	•65	•85	•93157	•25249	•15
•36	•93540	•24582	•64	•86	•93149	•25263	•14
•37	•93532	•24595	•63	•87	•93141	•25276	•13
•38	•93525	•24609	•62	•88	•93133	•25290	•12
•39	•93517	•24623	•61	•89	•93125	•25303	•11
•40	•93509	•24636	•60	•90	•93117	•25317	•10
•41	•93502	•24650	•59	•91	•93109	•25330	•09
•42	•93494	•24664	•58	•92	•93101	•25344	•08
•43	•93486	•24677	•57	•93	•93093	•25357	•07
•44	•93478	•24691	•56	•94	•93090	•25371	•06
•45	•93471	•24705	•55	•95	•93077	•25384	•05
•46	•93463	•24718	•54	•96	•93069	•25398	•04
•47	•93455	•24732	•53	•97	•93061	•25412	•03
•48	•93447	•24746	•52	•98	•93053	•25425	•02
•49	•93439	•24759	•51	•99	•93045	•25439	•01
116°50	•93432	•24773	83°50	117°00	•93037	•25452	83°00
	Distance.	Difference in Height.	Angle.		Distance.	Difference in Height.	Angle.

83 g.

117 g.

Angle.	Distance.	Difference in Height.		Angle.	Distance.	Difference in Height.	
117°00	·93037	·25452	83°00	117°50	·92632	·26125	82°50
·01	·93029	·25466	82°99	·51	·92624	·26138	·49
·02	·93021	·25479	·98	·52	·92616	·26152	·48
·03	·93013	·25493	·97	·53	·92607	·26165	·47
·04	·93005	·25506	·96	·54	·92599	·26178	·46
·05	·92997	·25520	·95	·55	·92591	·26192	·45
·06	·92989	·25533	·94	·56	·92583	·26205	·44
·07	·92981	·25547	·93	·57	·92574	·26219	·43
·08	·92973	·25560	·92	·58	·92566	·26232	·42
·09	·92965	·25574	·91	·59	·92558	·26245	·41
·10	·92957	·25587	·90	·60	·92550	·26259	·40
·11	·92949	·25601	·89	·61	·92541	·26272	·39
·12	·92941	·25614	·88	·62	·92533	·26285	·38
·13	·92933	·25628	·87	·63	·92525	·26299	·37
·14	·92925	·25641	·86	·64	·92517	·26312	·36
·15	·92917	·25655	·85	·65	·92508	·26326	·35
·16	·92909	·25668	·84	·66	·92500	·26339	·34
·17	·92901	·25682	·83	·67	·92492	·26352	·33
·18	·92893	·25695	·82	·68	·92484	·26366	·32
·19	·92885	·25709	·81	·69	·92475	·26379	·31
·20	·92876	·25722	·80	·70	·92467	·26392	·30
·21	·92868	·25736	·79	·71	·92459	·26406	·29
·22	·92860	·25749	·78	·72	·92450	·26419	·28
·23	·92852	·25763	·77	·73	·92442	·26432	·27
·24	·92844	·25776	·76	·74	·92434	·26446	·26
117°25	·92836	·25789	82°75	117°75	·92426	·26459	82°25
·26	·92828	·25803	·74	·76	·92417	·26472	·24
·27	·92820	·25816	·73	·77	·92409	·26486	·23
·28	·92812	·25830	·72	·78	·92401	·26499	·22
·29	·92803	·25843	·71	·79	·92392	·26512	·21
·30	·92795	·25857	·70	·80	·92384	·26526	·20
·31	·92787	·25870	·69	·81	·92376	·26539	·19
·32	·92779	·25883	·68	·82	·92367	·26552	·18
·33	·92771	·25897	·67	·83	·92359	·26566	·17
·34	·92763	·25910	·66	·84	·92351	·26579	·16
·35	·92755	·25924	·65	·85	·92342	·26592	·15
·36	·92747	·25937	·64	·86	·92334	·26605	·14
·37	·92738	·25951	·63	·87	·92325	·26619	·13
·38	·92730	·25964	·62	·88	·92317	·26632	·12
·39	·92722	·25978	·61	·89	·92309	·26645	·11
·40	·92714	·25991	·60	·90	·92300	·26659	·10
·41	·92706	·26004	·59	·91	·92292	·26672	·09
·42	·92698	·26018	·58	·92	·92284	·26685	·08
·43	·92689	·26031	·57	·93	·92275	·26698	·07
·44	·92681	·26045	·56	·94	·92267	·26712	·06
·45	·92673	·26058	·55	·95	·92258	·26725	·05
·46	·92665	·26071	·54	·96	·92250	·26738	·04
·47	·92657	·26085	·53	·97	·92242	·26752	·03
·48	·92648	·26098	·52	·98	·92233	·26765	·02
·49	·92640	·26112	·51	·99	·92225	·26778	·01
117°50	·92632	·26125	82°50	118°00	·92216	·26791	82°00
	Distance.	Difference in Height.	Angle.		Distance.	Difference in Height.	Angle.

118 g.

Angle.	Distance.	Difference in Height.		Angle.	Distance.	Difference in Height.	
118°00	•92216	•26791	82°00	118°50	•91790	•27451	81°50
•01	•92208	•26805	81°99	•51	•91782	•27464	•49
•02	•92200	•26818	•98	•52	•91773	•27477	•48
•03	•92191	•26831	•97	•53	•91765	•27491	•47
•04	•92183	•26844	•96	•54	•91756	•27504	•46
•05	•92174	•26858	•95	•55	•91747	•27517	•45
•06	•92166	•26871	•94	•56	•91739	•27530	•44
•07	•92157	•26884	•93	•57	•91730	•27543	•43
•08	•92149	•26897	•92	•58	•91721	•27556	•42
•09	•92140	•26911	•91	•59	•91713	•27569	•41
•10	•92132	•26924	•90	•60	•91704	•27582	•40
•11	•92124	•26937	•89	•61	•91695	•27595	•39
•12	•92115	•26950	•88	•62	•91687	•27609	•38
•13	•92107	•26964	•87	•63	•91678	•27622	•37
•14	•92098	•26977	•86	•64	•91669	•27635	•36
•15	•92090	•26990	•85	•65	•91661	•27648	•35
•16	•92081	•27003	•84	•66	•91652	•27661	•34
•17	•92073	•27016	•83	•67	•91643	•27674	•33
•18	•92064	•27030	•82	•68	•91635	•27687	•32
•19	•92056	•27043	•81	•69	•91626	•27700	•31
•20	•92047	•27056	•80	•70	•91617	•27713	•30
•21	•92039	•27069	•79	•71	•91608	•27726	•29
•22	•92030	•27083	•78	•72	•91600	•27739	•28
•23	•92022	•27096	•77	•73	•91591	•27752	•27
•24	•92013	•27109	•76	•74	•91582	•27765	•26
118°25	•92005	•27122	81°75	118°75	•91574	•27779	81°25
•26	•91996	•27135	•74	•76	•91565	•27792	•24
•27	•91988	•27148	•73	•77	•91556	•27805	•23
•28	•91979	•27162	•72	•78	•91547	•27818	•22
•29	•91971	•27175	•71	•79	•91539	•27831	•21
•30	•91962	•27188	•70	•80	•91530	•27844	•20
•31	•91953	•27201	•69	•81	•91521	•27857	•19
•32	•91945	•27214	•68	•82	•91512	•27870	•18
•33	•91936	•27228	•67	•83	•91504	•27883	•17
•34	•91928	•27241	•66	•84	•91495	•27896	•16
•35	•91919	•27254	•65	•85	•91486	•27909	•15
•36	•91911	•27267	•64	•86	•91477	•27922	•14
•37	•91902	•27280	•63	•87	•91468	•27935	•13
•38	•91894	•27293	•62	•88	•91460	•27948	•12
•39	•91885	•27307	•61	•89	•91451	•27961	•11
•40	•91876	•27320	•60	•90	•91442	•27974	•10
•41	•91868	•27333	•59	•91	•91433	•27987	•09
•42	•91859	•27346	•58	•92	•91425	•28000	•08
•43	•91851	•27359	•57	•93	•91416	•28013	•07
•44	•91842	•27372	•56	•94	•91407	•28026	•06
•45	•91833	•27385	•55	•95	•91398	•28039	•05
•46	•91825	•27399	•54	•96	•91389	•28052	•04
•47	•91816	•27412	•53	•97	•91380	•28065	•03
•48	•91808	•27425	•52	•98	•91372	•28078	•02
•49	•91799	•27438	•51	•99	•91363	•28091	•01
118°50	•91790	•27451	81°50	119°00	•91354	•28104	81°00
	Distance.	Difference in Height.	Angle.		Distance.	Difference in Height.	Angle.

119 g.

Angle.	Distance.	Difference in Height.		Angle.	Distance.	Difference in Height.	
119°00	·91354	·28104	81°00	119°50	·90908	·28750	80°50
·01	·91345	·28117	80°99	·51	·90899	·28763	·49
·02	·91336	·28130	·98	·52	·90889	·28776	·48
·03	·91328	·28143	·97	·53	·90880	·28789	·47
·04	·91319	·28156	·96	·54	·90871	·28802	·46
·05	·91310	·28169	·95	·55	·90862	·28815	·45
·06	·91301	·28182	·94	·56	·90853	·28827	·44
·07	·91292	·28195	·93	·57	·90844	·28840	·43
·08	·91283	·28208	·92	·58	·90835	·28853	·42
·09	·91274	·28221	·91	·59	·90826	·28866	·41
·10	·91266	·28234	·90	·60	·90817	·28879	·40
·11	·91257	·28247	·89	·61	·90808	·28891	·39
·12	·91248	·28260	·88	·62	·90799	·28904	·38
·13	·91239	·28273	·87	·63	·90790	·28917	·37
·14	·91230	·28286	·86	·64	·90781	·28930	·36
·15	·91221	·28299	·85	·65	·90772	·28943	·35
·16	·91212	·28312	·84	·66	·90762	·28956	·34
·17	·91203	·28325	·83	·67	·90753	·28968	·33
·18	·91194	·28338	·82	·68	·90744	·28981	·32
·19	·91186	·28351	·81	·69	·90735	·28994	·31
·20	·91177	·28364	·80	·70	·90726	·29007	·30
·21	·91168	·28376	·79	·71	·90717	·29020	·29
·22	·91159	·28389	·78	·72	·90708	·29032	·28
·23	·91150	·28402	·77	·73	·90699	·29045	·27
·24	·91141	·28415	·76	·74	·90690	·29058	·26
119°25	·91132	·28428	80°75	119°75	·90680	·29071	80°25
·26	·91123	·28441	·74	·76	·90671	·29083	·24
·27	·91114	·28454	·73	·77	·90662	·29096	·23
·28	·91105	·28467	·72	·78	·90653	·29109	·22
·29	·91096	·28480	·71	·79	·90644	·29122	·21
·30	·91087	·28493	·70	·80	·90635	·29135	·20
·31	·91078	·28506	·69	·81	·90626	·29147	·19
·32	·91069	·28519	·68	·82	·90616	·29160	·18
·33	·91060	·28531	·67	·83	·90607	·29173	·17
·34	·91051	·28544	·66	·84	·90598	·29186	·16
·35	·91043	·28557	·65	·85	·90589	·29198	·15
·36	·91034	·28570	·64	·86	·90580	·29211	·14
·37	·91025	·28583	·63	·87	·90571	·29224	·13
·38	·91016	·28596	·62	·88	·90561	·29237	·12
·39	·91007	·28609	·61	·89	·90552	·29249	·11
·40	·90998	·28622	·60	·90	·90543	·29262	·10
·41	·90989	·28635	·59	·91	·90534	·29275	·09
·42	·90980	·28647	·58	·92	·90525	·29288	·08
·43	·90971	·28660	·57	·93	·90515	·29300	·07
·44	·90962	·28673	·56	·94	·90506	·29313	·06
·45	·90953	·28686	·55	·95	·90497	·29326	·05
·46	·90944	·28699	·54	·96	·90488	·29338	·04
·47	·90935	·28712	·53	·97	·90479	·29351	·03
·48	·90926	·28725	·52	·98	·90469	·29364	·02
·49	·90917	·28737	·51	·99	·90460	·29377	·01
119°50	·90908	·28750	80°50	120°00	·90451	·29389	80°00
	Distance.	Difference in Height.	Angle.		Distance.	Difference in Height.	Angle.

APPENDIX No. IV.

TABLE FOR REDUCING CENTESIMAL GRADUATIONS
TO SEXAGESIMAL, AND *VICE VERSÂ*.

TABLE FOR REDUCING CENTESIMAL GRADUATIONS TO SEXAGESIMAL,
AND VICE VERSÂ.

Centesimal Graduations.	Equivalent in Sexagesimal Graduations.			Sexagesimal Graduations.	Equivalent in Centesimal Graduations.
<i>g.</i>	Degrees.	Minutes.	Seconds.	Seconds.	<i>g.</i>
0·01	—	—	32·4	1	0·00031
0·02	—	1	4·8	2	0·00062
0·03	—	1	37·2	3	0·00093
0·04	—	2	9·6	4	0·00123
0·05	—	2	42·0	5	0·00154
0·06	—	3	14·4	6	0·00185
0·07	—	3	46·8	7	0·00216
0·08	—	4	19·2	8	0·00247
0·09	—	4	51·6	9	0·00278
<i>g.</i>				Minutes.	<i>g.</i>
0·10	—	5	24	1	0·01852
0·20	—	10	48	2	0·03704
0·30	—	16	12	3	0·05556
0·40	—	21	36	4	0·07407
0·50	—	27	0	5	0·09259
0·60	—	32	24	6	0·11111
0·70	—	37	48	7	0·12963
0·80	—	43	12	8	0·14815
0·90	—	48	36	9	0·16667
<i>g.</i>				Degrees.	<i>g.</i>
1·00	—	54	—	1	1·11111
2·00	1	48	—	2	2·22222
3·00	2	42	—	3	3·33333
4·00	3	36	—	4	4·44444
5·00	4	30	—	5	5·55556
6·00	5	24	—	6	6·66667
7·00	6	18	—	7	7·77778
8·00	7	12	—	8	8·88889
9·00	8	6	—	9	10·00000
10·00	9	—	—	10	11·11111
20·00	18	—	—	20	22·22222
30·00	27	—	—	30	33·33333
40·00	36	—	—	40	44·44444
50·00	45	—	—	50	55·55556
60·00	54	—	—	60	66·66667
70·00	63	—	—	70	77·77778
80·00	72	—	—	80	88·88889
90·00	81	—	—	90	100·00000
100·00	90	—	—	100	111·11111

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